ENVIRONMENTAL (IN)JUSTICE AND 'EXPERT KNOWLEDGE': THE DISCURSIVE CONSTRUCTION OF DIOXINS, 2,4,5-T AND HUMAN HEALTH IN NEW ZEALAND, 1940 TO 2007

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BRUCE WILDBLOOD-CRAWFORD
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Abstract

This thesis examines the discourses of human health and synthetic chemicals that emerged in New Zealand, focusing specifically on the 1970s dioxin controversy. Dioxins were highly toxic contaminants in the herbicide 2,4,5-T, one of the country's most widely used agricultural chemicals from 1948 to 1987. The theoretical framework of the thesis is grounded in poststructural notions about power/knowledge and ideas from sociology and science studies that highlight the inevitable uncertainties that surround human exposure to chemicals. Archival material from the Agricultural Chemicals Board and the Department of Health, chemical industry publications and a range of other textual materials were analysed using a discourse methodology that focused on intertextuality. To better understand the discursive construction of dioxins in New Zealand, the role of the chemical industry, government and opposition groups in constructing, resisting and politicising dioxins is described. The thesis reconceptualizes environmental (in)justices as not exclusively local, but as boundless, discursive and socio-historic in character. It also reflects on how resolving contemporary dioxin injustices in New Zealand, themselves the result of historical exposures, are problematically still being approached primarily through a reductionist approach to health and chemicals.

This thesis is dedicated to everybody who has been affected by dioxins, but especially to the employees of the sawmill and chemical industries, to the soldiers, to the mothers and to the families

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Common Abbreviations & Terms

ACB: New Zealand Agricultural Chemicals Board

DOA: New Zealand Department of Agriculture

DOH: New Zealand Department of Health

Dow: Dow Chemicals USA Ltd

DSIR: New Zealand Department of Scientific and Industrial Research

IW: Ivon Watkins Ltd.

IWD: Ivon Watkins-Dow Ltd *Following common usage and to avoid confusion, IWD is use throughout. The exception is where clear reference is being made to pre-1964, then IW is employed and for more contemporary references, DowAgroSciences (NZ) Ltd. is used.*

MFE: New Zealand Ministry for the Environment

MOH: New Zealand Ministry of Health

TCP: Tetrachlorophenol

Dioxin, dioxins and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

Today, the term 'dioxin' is often used to describe the chlorinated dibenzodioxins family, which is composed of 75 structurally similar molecules that exhibit varying degrees of toxicity. The best-known and most toxic of these is 2,3,7,8-tetrachlorodibenzo-p-dioxin, or TCDD. During the 1970s, the legislative and public focus on dioxins was on TCDD. This was because not much was known about the other 74 dioxins and the extreme toxicity of TCDD warranted the most attention. However, the term TCDD was not always used, and instead 'dioxin' or 'dioxins' became common.

Throughout this thesis I have tried to use the term TCDD only in places where it is important to distinguish the specific molecule. For instance, in the case of the analytical monitoring of dioxins described in Chapter 7, the chemical industry and government agencies were specifically testing for only TCDD. However, I use the term dioxin/dioxins in other places in recognition that while TCDD is the most toxic, the other 74 dioxins also exhibited toxic affects and are better thought of as a group of structurally similar molecules, even though they essentially were not conceptualised as such until the 1980s.

Chapter 1: The contested past and present spaces of dioxin governance

The growth of the international chemical industry is arguably one of the most significant features of the twentieth century. Fuelled by wartime research funding and a rapid succession of technological breakthroughs, the outcomes of industrial chemistry are evident in nearly every aspect of global capital's expansion, particularly since Second World War. Be they plastics, penicillin, food preservatives or petroleum, the products of chemistry in many ways define modernity. Such a defining role in our daily lives has also positioned the chemical industry as a key facet and contributor to the Western rationality of progress. The growth of the chemical industry has allowed a connecting of 'techno-dreams of progress with nation-building activities such as design, transportation, agriculture, medicine and militarism' (Casper 2003: xvi).

But whether or not Dupont's old corporate slogan that 'Better Things for Better Living Through Chemistry' is true, the unprecedented twentieth century growth in chemical production has stimulated wide-ranging debates on the unwanted impact of such substances on society. Central to these debates is whether the products of industrial chemistry have a substantial negative effect on human and ecosystem health. Critics of the role of chemicals in society question the ability of science to accurately assess human exposures to chemicals and whether such 'environmental risks' are sufficiently addressed by industry and governments.

Sociologist Monica Casper (2003: xvii) has noted that this Janus-faced quality of industrial chemicals as ‘both beneficial and insidious’ has resulted in new social and political arrangements. She suggests that the movement of chemicals from factories and laboratories and their penetration into and between bodies, communities, environments and nations have created distinct *chemical politics*. One element of such politics is that they are composed of competing discourses about chemicals, health and science. ‘Discourse’ is used here in the broadest Foucauldian sense to mean a systematic set of statements or signs represented in various ‘texts’ (Foucault 1972).

This thesis focuses on one example of chemical politics and its formative discourses by examining the New Zealand history of the herbicide 2,4,5-T, and the infamous dioxin contaminants it contained. 2,4,5-T and dioxins provide an ideal case study for Casper’s notion that chemicals constitute and are constituted by a variety of spaces, and that, as such, they transform the social and political fabric. The following chapters describe and critically analyses the emergence of risk assessment as a governance strategy in New Zealand through a case study of the dioxin contaminants in the herbicide 2,4,5-T. Following poststructural insights into power, knowledge and discourse, risk assessment and dioxins are conceptualised as embodying specific notions of truth and rationality that have arisen in a distinct period.

The remainder of this introductory chapter is in three parts. The first employs Casper’s notion that we should ‘follow the molecule’ (2003: xxiii) to understand how chemicals change society by their movement through different scales and across time. It provides context for the remaining chapters by sketching the major themes of New Zealand’s dioxin history, particularly the tensions between a contested past and present. In the second section, attention is turned to briefly exploring how popular and academic accounts have approached critically understanding the scientific, political and social contestations that have emerged around chemicals. Thirdly, the approach taken in the following chapters to understanding such debates, which focuses on governance, power/knowledge and risk, is briefly outlined through a discussion of the research questions that are considered, and the methodology and structure that are employed.

New Zealand's 2,4,5-T and dioxin history

The herbicide 2,4,5-T was a product of the post-war agrochemical revolution and was used in New Zealand from 1948 to 1988, becoming a central weapon in the farmer's 'war against weeds' (Figure 1). A range of intentionally and unintentionally introduced invasive weeds flourished in New Zealand and were regarded as a threat to agricultural productivity. What made 2,4,5-T so beneficial was its 'selectivity' meaning that unwanted brush weeds such as gorse and blackberry could be destroyed, while pasture grasses remained unharmed. Because New Zealand was reliant on pasture-based agricultural production for its economic foundation and stability, the post-Second World War prospects of selective weedkilling chemicals were profound. Increased productivity per unit and the conversion of 'wastelands' into pasture, were made considerably easier through the use of 2,4,5-T. While underway since the early 1900s, New Zealand's 'grasslands revolution' was materially enhanced by DDT, 2,4,5-T and the widespread aerial application of superphosphate fertilizers (Brooking et al. 2002; Chapter 4). In a wide range of popular and government texts, utopian discourses of progress symbolically constructed agrochemicals as a panacea linking national prosperity to a seemingly blind faith in the ability of science, and chemicals, to facilitate economic growth.

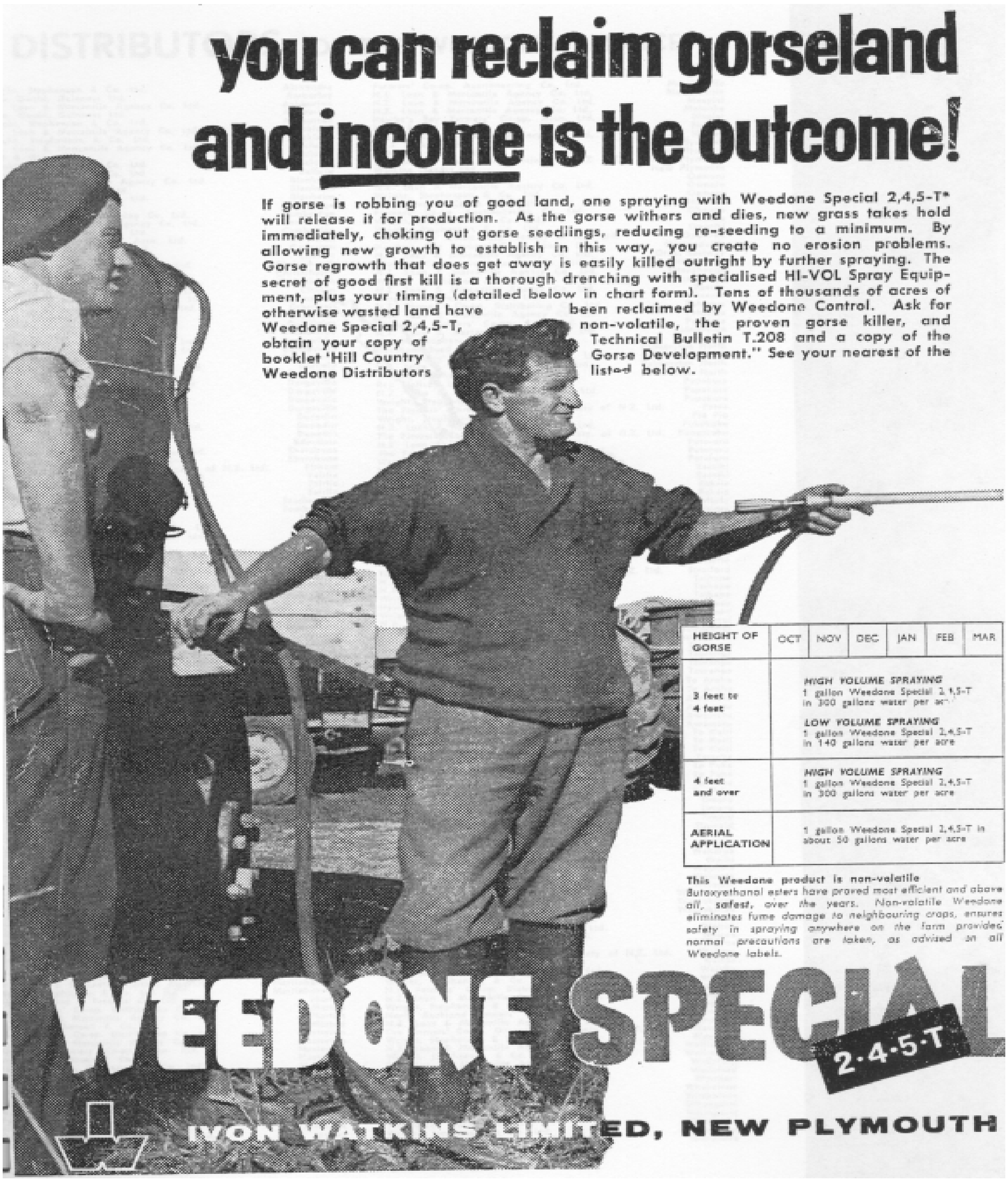
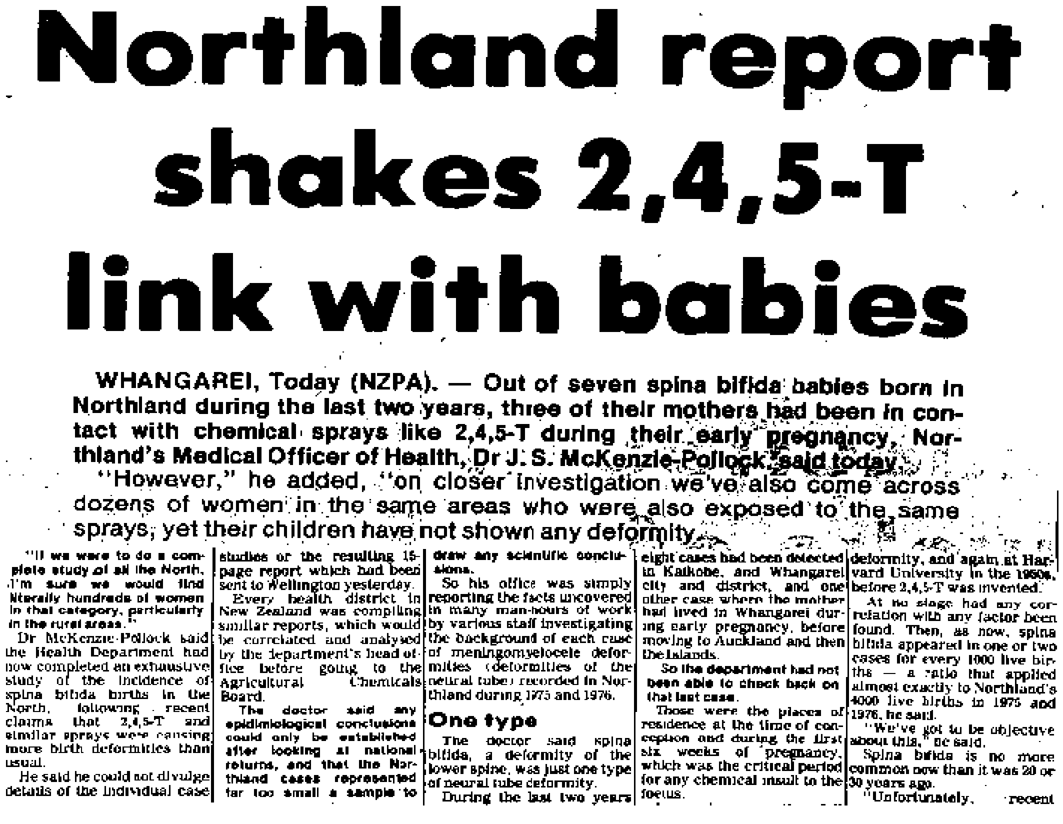


Figure 1 Typical 1950's advertisement for 2,4,5-T showing the role of herbicides in the farmers 'war on weeds' (*Source* Ivon Watkins 1959a: 27)

The widespread use of 2,4,5-T in New Zealand is also an example of the unwanted and damaging implications of synthetic chemistry and how such effects have been widely contested across space and time by citizen movements, governments and the chemical industry. The chemical reactions inherent in the manufacturing process of 2,4,5-T resulted in the production of unwanted contaminants known as ‘dioxins’. Today, the term ‘dioxin’ is often used to describe the chlorinated dibenzodioxins family, which is composed of structurally similar molecules that exhibit varying degrees of toxicity (Ministry of Health [MOH] 2007). The best-known of these is 2,3,7,8-tetrachlorodibenzo-p-dioxin, or TCDD (see Abbreviations & Terms), which is the most carcinogenic synthetic chemical in existence. The human health effects of TCDD, while debated, are generally acknowledged today to include certain forms of cancer, endometriosis, generalised disruption of the endocrine system, and a range of developmental and reproductive disorders (Schecter & Gasiewicz 2003). However, these contemporary understandings of dioxin toxicity belie the extent to which its health and environmental effects have been bitterly contested internationally and in New Zealand for over 35 years.

While dioxins were present in every batch of 2,4,5-T made from the early 1940s, and the chemical industry was aware of their existence in the late 1950s, such knowledge did not become public until late 1969. These nascent understandings of dioxins emerged into social and political landscapes where the effects of chemicals on human and environmental health were beginning to be critically questioned, in part fuelled by Rachel Carson’s 1962 *Silent Spring* and the ensuing debates surrounding the book. In New Zealand, the dioxin contamination of 2,4,5-T became a persistent public health issue nationally from 1970 onwards. The media and the public, in part encouraged by the 1970 banning of the prominent agricultural chemical DDT, began to voice concern over whether dioxins were teratogenic (causing birth defects). The reporting of alleged birth defects clusters throughout New Zealand during the 1970s and 1980s and accusations of health effects by a minority of scientists, medical professionals, local councils and citizen groups caused public debate about dioxins (Figure 2). Central to these debates were arguments that government and the chemical industry were putting economic concerns ahead of human health, and that the ability of science to actually 'know' about chemical exposure was limited. Thus, the public's response to the purported health effects of dioxins represented a challenge to the hegemonic construction of agricultural chemicals so pervasive in New Zealand during the 1950s and 60s.



Northland report shakes 2,4,5-T link with babies

WHANGAREI, Today (NZPA). — Out of seven spina bifida babies born in Northland during the last two years, three of their mothers had been in contact with chemical sprays like 2,4,5-T during their early pregnancy, Northland's Medical Officer of Health, Dr J. S. McKenzie-Pollock said today.

"However," he added, "on closer investigation we've also come across dozens of women in the same areas who were also exposed to the same sprays, yet their children have not shown any deformity.

"If we were to do a complete study of all the North, I'm sure we would find literally hundreds of women in that category, particularly in the rural areas."

Dr McKenzie-Pollock said the Health Department had now completed an exhaustive study of the incidence of spina bifida births in the North, following recent claims that 2,4,5-T and similar sprays were causing more birth deformities than usual.

He said he could not divulge details of the individual case studies or the resulting 15-page report which had been sent to Wellington yesterday.

Every health district in New Zealand was compiling similar reports, which would be correlated and analysed by the department's head office before going to the Agricultural Chemicals Board.

The doctor said any epidemiological conclusions could only be established after looking at national returns, and that the Northland cases represented far too small a sample to draw any scientific conclusions.

So his office was simply reporting the facts uncovered in many man-hours of work by various staff investigating the background of each case of meningomyelocele deformities (deformities of the neural tube) recorded in Northland during 1975 and 1976.

One type

The doctor said spina bifida, a deformity of the lower spine, was just one type of neural tube deformity.

During the last two years eight cases had been detected in Kaikohe, and Whangarei city and district, and one other case where the mother had lived in Whangarei during early pregnancy, before moving to Auckland and then the Islands.

So the department had not been able to check back on that last case.

Those were the places of residence at the time of conception and during the first six weeks of pregnancy, which was the critical period for any chemical insult to the foetus.

[illegible] deformity, and again at Harvard University in the 1950s, before 2,4,5-T was invented.

At no stage had any correlation with any factor been found. Then, as now, spina bifida appeared in one or two cases for every 1000 live births — a ratio that applied almost exactly to Northland's 4000 live births in 1975 and 1976, he said.

"We've got to be objective about this," he said.

Spina bifida is no more common now than it was 20 or 30 years ago.

"Unfortunately, recent

Figure 2 New Zealand Herald article describing a series of reported birth defects in Northland, New Zealand (*Source* New Zealand Herald 1977)

Throughout the 1970s and the early 1980s, various New Zealand government agencies and the chemical industry effectively rebutted these concerns about dioxins and human health. Relying primarily on overseas research and several high profile Department of Health (DOH) reports, they contended that dioxins were potentially harmful only at high doses unattainable through ‘normal’ exposure. Using toxicological and epidemiological evidence they maintained that the amounts found in 2,4,5-T and their associated manufacturing wastes (by the 1980s being measured in parts per trillion) were sufficiently low to cause no human health effects. During most of the 1970s, New Zealand’s stance towards dioxins was echoed globally by numerous governments that sought to ‘balance’ the risks of pesticide use against their widespread benefits. The use of 2,4,5-T in New Zealand, bolstered by government subsidies, steadily increased during this time (Figure 3), giving the country the eventual reputation as the largest per capita user of the herbicide (Brinkman 1986; Baker et al. 2003).

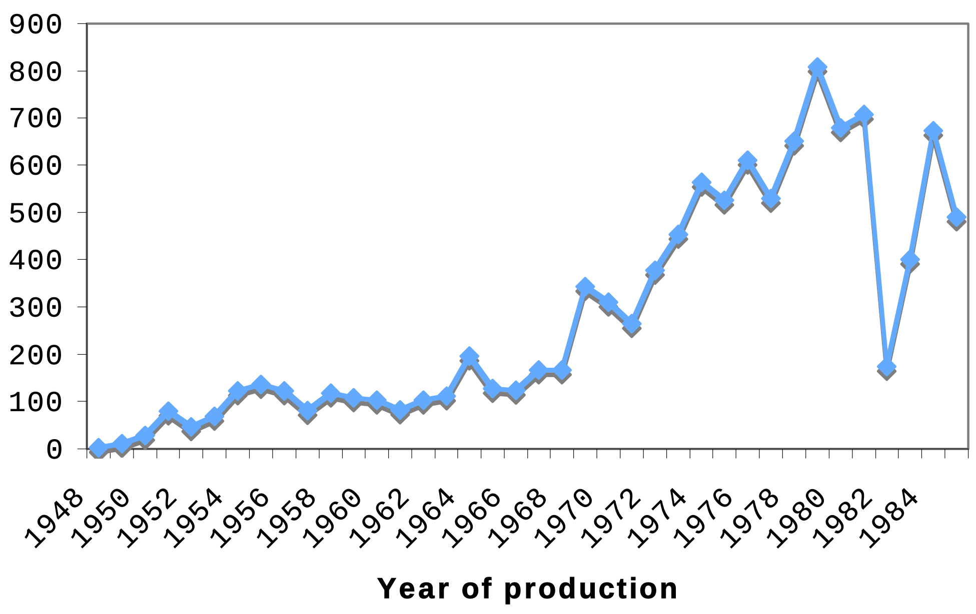


Figure 3 Production of 2,4,5-T in New Zealand by Ivon Watkins-Dow 1948-1985 according to figures supplied by company (*Source* Coster et al. 1986)

By the early 1980s, the science and politics of dioxins had become more sharply contested. Revelations that there was a high level of dioxin contamination in Agent Orange, a 50:50 mixture of 2,4,5-T & 2,4-D used by the US military during the Vietnam war as a defoliant led to claims that several million US veterans were experiencing dioxin-related health ailments (Figure 4). In 1983, US veterans sued the manufacturers of Agent Orange in what was then the largest civil legal action ever undertaken. By 1985, many Western countries had banned 2,4,5-T citing uncertainties about dioxins and its human health effects. Yet in New Zealand, 2,4,5-T use, continued to increase. When the manufacture and use of 2,4,5-T finally ceased in 1987, New Zealand had been one of the last countries in the world producing the dioxin-contaminated herbicide.

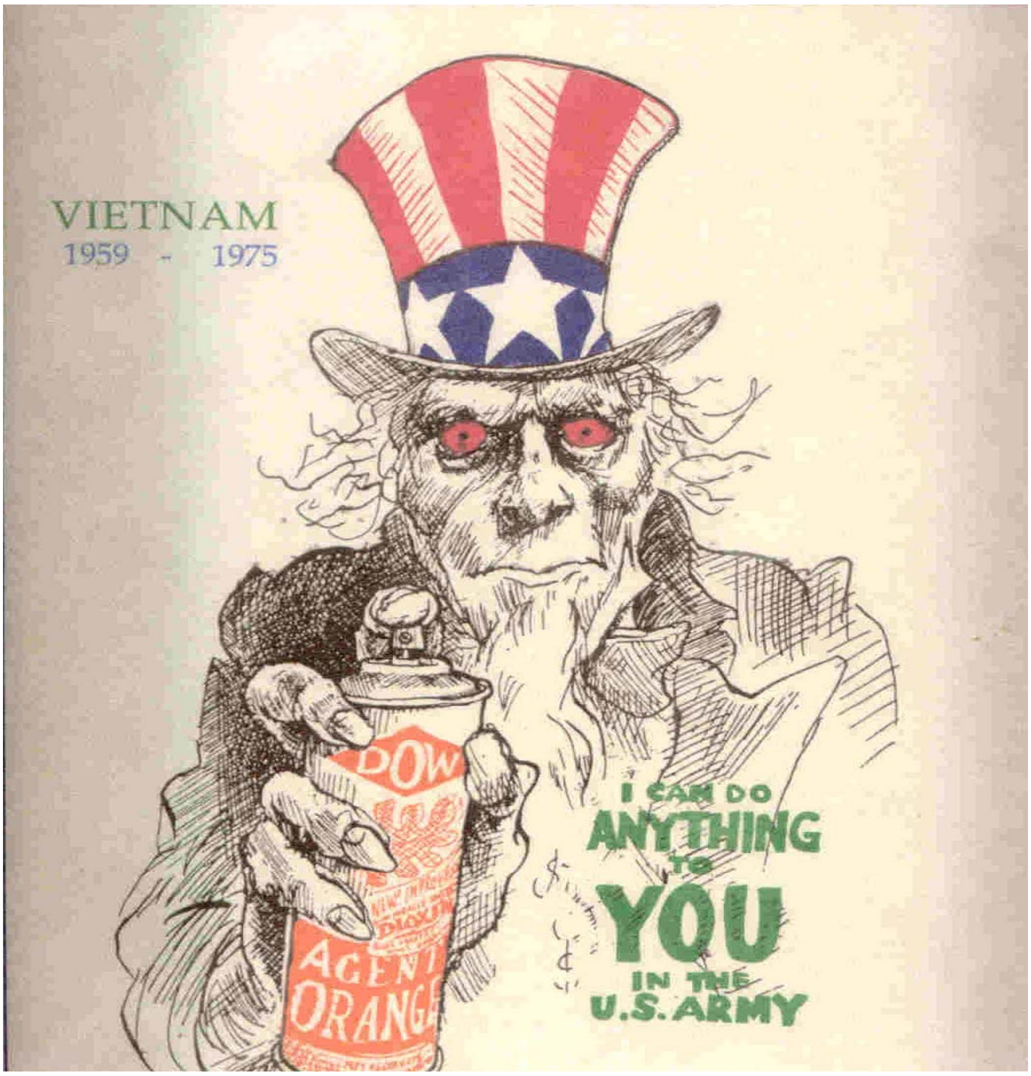


Figure 4 Early 1980s US Vietnam veterans poster (*Source*: http://womenveterans.homestead.com/AgentOrange.html)

The preceding has highlighted how dioxins move through and constitute national and international spaces. Yet, local spaces are also important. The majority of 2,4,5-T used in New Zealand was produced by one manufacturer at a single factory in New Plymouth, a small town on the west coast of the country's North Island (Figure 5). Still operating today as DowAgroSciences (NZ) Ltd, the company was for many years known as Ivon Watkins (IW). It was started by three New Zealand brothers in 1944 and grew into the country's sole manufacturer of 2,4,5-T and a market leader in numerous other agrochemicals, veterinary medicines, detergents and industrial chemicals.

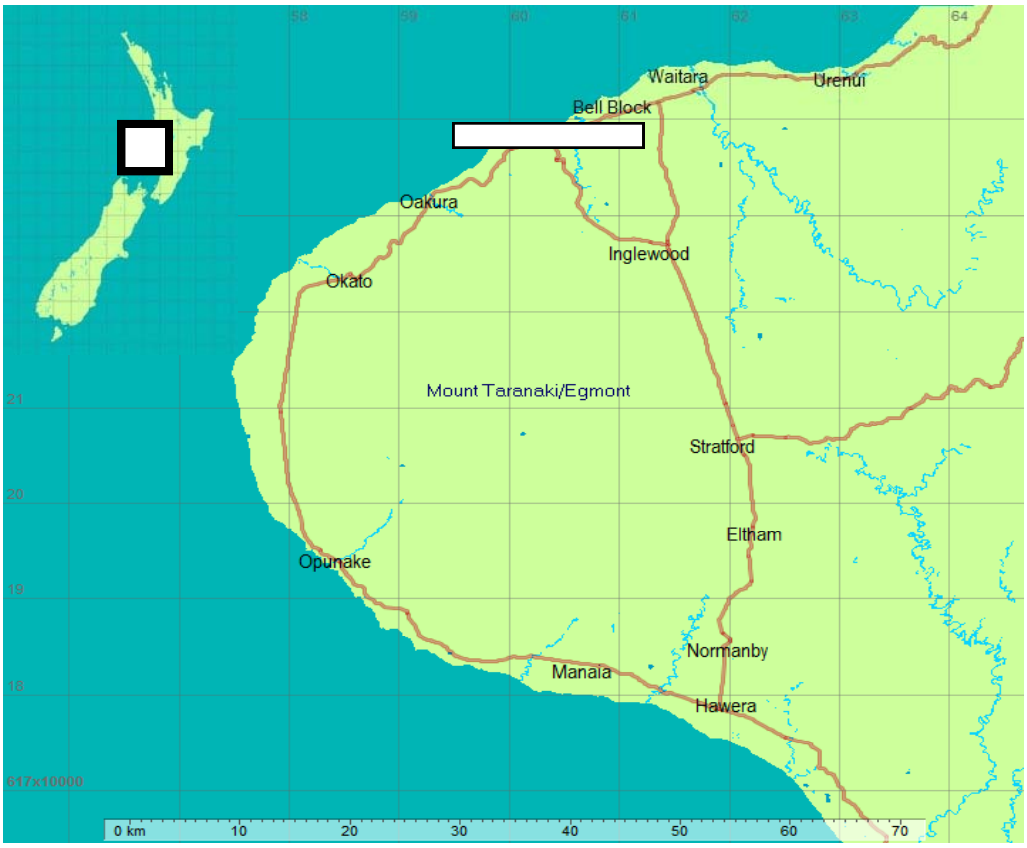


Figure 5 Map showing the Taranaki region and the town of New Plymouth (*Source*: TUMONZ version 3.0)

While IW prided itself on research and development geared towards New Zealand conditions, several major international chemical firms had substantial financial interests in the company including Monsanto (USA), the American Chemical Paint Company (USA), Geigy (Switzerland), Cela (Germany) and the Union Carbide Corporation (USA). Solidifying such connections, the company became Ivon Watkins-Dow Ltd (IWD) in 1964 after Dow Chemicals USA bought a 50% interest (Sewell 1978). These corporate relationships allowed the importation of vital raw materials, formulation patents and product ideas. However, they also positioned IWD within flows of symbolic and political capital, such as advertising and regulatory reform strategies, which the international chemical industry relied on to enhance their market position, and to eventually defend the safety record of their products.

Besides these international connections, IWD also typify how the production of chemicals affects physical and social environments. Between 1944 and 1959 the company operated several small factories in downtown New Plymouth including one on Devon Street, St. Aubyn Street and Buller Street (IWD 1960: 5–7). At these early premises they formulated chemicals, which means chemicals were mixed together to create a useable product without creating any new chemical substances. This changed in 1959 when the company built a factory in the New Plymouth neighborhood of Paritutu capable of creating new chemical substances and manufacturing them on a large scale. In the mid-1960s, the factory became a source of contestation when residents began complaining about the potential for health effects from fugitive air emissions and waste-water discharges. During the mid-1970s, with the production of 2,4,5-T nearing 500,000 litres annually, the disposal of dioxin-contaminated production wastes began in a DOH licensed incinerator located at the factory site in Paritutu. While the health effects of dioxins were being loudly debated throughout New Zealand, the neighborhoods surrounding the IWD factory became silent spaces of widespread dioxin pollution. These silences were broken in 1985 when several local resident groups contested New Plymouth dioxin contamination and human health effects. These actions, and an explosion at the plant, led to a 1986 Ministerial Committee of Inquiry that found the accident and overall 2,4,5-T production had caused no health effects amongst local residents (Brinkman 1986, 1987).

A disputed past and a contested present

In August 1987, IWD announced they would cease production of 2,4,5-T by the end of the year. While existing stocks of the herbicide remained on sale until December 1988, the long and often bitter struggle over 2,4,5-T and dioxins in New Zealand appeared to lessen with the end of production in 1987 (Syme 1988: 1). By 1989 a Ministry for the Environment (MFE) report (1989: 16) stated that

> Ivon Watkins-Dow Ltd have ceased manufacture of 2,4,5-T and warehouse stocks are depleted. Any need to resolve outstanding questions associated with the manufacture of 2,4,5-T have therefore been annulled.

However, such a narrow conceptualisation of dioxins and the contestation they generate has proved to be short-sighted. Instead, the ‘outstanding questions’ regarding 2,4,5-T production have become prominent in two disparate efforts over the last 12 years, which reflect changing attitudes toward the political and scientific status of dioxins.

The first has been an increased focus by the New Zealand government. In 1995, the MFE initiated the Organochlorines Programme, a research strategy that has comprehensively assessed the level of dioxins and other organochlorine chemicals like PCB’s in New Zealand’s food chain (Buckland et al. 1998), air, land and water (Buckland et al. 2000), breast milk (Bates 1990) and general population (Buckland 2001), and has created a plan for reducing overall emissions and human exposures (MFE 1997; Smith & Lopipero 2001). Despite the banning of 2,4,5-T, dioxins are still produced and released into the environment through numerous combustion processes including ‘backyard’ waste burning, crematoria, some metallurgic processes and the industrial incineration of hazardous and medical wastes. The quantities created through these processes are exponentially smaller than the amounts produced historically by 2,4,5-T manufacture. However, since the 1990s it has been suggested that long-term exposure to tiny amounts of dioxins, at the parts per trillion level, may have a substantial long-term effect on human health (Webster & Commoner 2003). In a related but less publicised and less structured initiative, the Organochlorines Programme has also sought to address historical contamination of the environment caused by organochlorine use and production. This has involved the identification of unlicensed waste dumps around the country and several large-scale remediation efforts (MFE 2003, 2006a).

The second effort that has ensured 2,4,5-T and dioxins remain prominent public issues in New Zealand is social movements that have sought to redress what their participants perceive as the human and environmental damage caused by the chemicals. The three most prominent groups have been the country's Vietnam veterans who were exposed to numerous chemicals including Agent Orange (Challinor 1998; Challinor & Lancaster 2000; Advisory Committee on the Health of Veterans' Children 1999; Foreign Affairs & Defence Committee 1990), sawmill workers exposed to dioxins through the use of the wood preservative pentachlorophenol (PCP) (Dew 1999, 2002; Gorman et al. 2001; Jackman 1992, 1993), and residents and factory workers in New Plymouth exposed to dioxins from 2,4,5-T production at the IWD plant (Allen & Clarke 2007; Baker et al. 2003; Fowles et al. 2005; Lucy & Proffitt 2002; MOH 2006; O'Connor 2001, 2002; Read & Wright 2005). These groups have challenged the idealistic image of New Zealand as a 'clean green' nation by raising awareness of the current human and environmental contamination that has resulted from the country's past industrial practices (Dew 1999).

The primary arguments and demands of these movements are on this nexus between past and present. While ongoing dioxin exposure occurs through the present contamination of our food chain, these groups received disproportionately high exposures 30 to 40 years ago. Thus, they have lobbied for not only adequate health care for those exposed, but also apologies and a full accounting of past government and industry practices, arguing that without the later two, a satisfactory resolution is impossible.

Situating dioxins within the spaces of science and risk assessment

The previous section outlined the contested past of dioxins in New Zealand and how it interacts with the present. While not exhaustive, four broad sets of actors can be identified within these narratives. First are social movements, variously conceptualised as individuals through to large non-governmental organisations, which critically question chemicals on the basis of health and environmental effects. Second are the numerous government entities that are vested with the responsibility to maintain human, social and environmental well-being. Third is the chemical industry that manufactures the chemicals and is sometimes legally, and arguably ethically, responsible for the effects related to their production. Finally, dioxin molecules can be conceptualised as having agency through their durability and ability to move between, penetrate into, and variously affect different spaces and scales.

Numerous theoretical orientations have been used to understand the interactions between these actors and the social and political structures that frame chemical issues. In beginning to sketch the specific theoretical framework that will be applied later, it is useful here to explore several key insights that have emerged out of academic and, to a lesser extent, popular literature. Two themes in particular have engendered a wide range of work.

First, studies in sociology (Brown 1997; Brown et al. 2001; Hofrichter 2000; Kroll-Smith et al. 2000) and science and technology studies (Hilgartner 2000; Jasanoff 2004) have demonstrated the considerable amount of scientific uncertainty prevalent in human–environment–society–chemical interactions. The notion that science is limited and unable to obtain adequate knowledge to, for instance inform policy making, is not in itself unusual. However, critics argue that toxicology and epidemiology, the primary scientific fields employed to understand chemical exposure, are chronically plagued with unknowns.

One reason for this is that like many scientific fields, epidemiology and toxicology adhere to an analytical approach that is characterized by Cartesian reductionism, where factors are considered in isolation from their contexts. However, real-world exposures usually include synergistic effects caused by multiple pollutants over varying temporal and spatial scales that challenge reductionism to distinguish causative factors. These features have led Kroll-Smith (2000: 10) to conclude that understanding the complexities of human exposures to chemicals is hindered by the 'endemic presence of uncertain knowledge'.

Secondly, research in public health studies (Markowitz & Rosner 2002) and sociology (Hofrichter 1993, 2000; Tesh 2000) has highlighted how the uncertainties of science become politicised, particularly as they relate to the regulation of industrial activities. In a paper summarising a range of public health research on the lead (Markowitz & Rosner 2000, 2002), asbestos (Brodeur 1985; Castleman 1984; Ozonoff 1988), and chemical industries (Miller 1999; When 1995), Michaels and Monforton (2005) suggest it has and continues to be commonplace for industry, government and non-government organisations to utilise scientific uncertainty in applying two related strategies to the legal, regulatory and public relations arenas. First, the uncertainty in establishing clear causative proof is widely used as evidence to continue the production of suspected toxins until 'clearer' evidence is available. The ability of the tobacco industry to forestall significant legal actions until the 1990s despite overwhelming evidence since the 1960s that smoking caused lung cancer is perhaps the clearest example. Internal tobacco industry documents demonstrate that a public relations plan developed in the mid-1950s was premised on promoting a message that 'room for responsible disagreement' existed within the available scientific evidence (Proctor 2004: 1174).

The second strategy that exploits the existence of uncertainty is termed the 'junk science' movement. This entails the strategic 'influencing of public opinion by ridiculing scientists whose research threatens powerful interests, irrespective of the quality of those scientists' research' (Michaels & Monforton 2005: S39–40). Uncertainty always exists and therefore provides an entry point for results to be disputed on a range of methodological, empirical, and arguably, political grounds.

The junk science strategy is operationalised in a variety of ways, including: denying research funding, advertising, political lobbying and character defamation.

Risk and the governance of dioxins

Casper's idea that we 'follow the molecule' has demonstrated how dioxins transform the social and political fabric across time and through space. However, a significant omission in the discussion thus far is how society, conceptualised in the broadest sense, has attempted to regulate and minimise the negative effects of chemicals. The following chapters argue that a distinct form of governance arose in the 1970s in parallel with the contestations around dioxins. While not widely termed 'risk assessment' until the late 1970s, what eventually became this governance strategy was undergoing a particularly fertile period of development in the early 1970s, especially around dioxin issues. Governance here refers to something broader than government in the conventional sense of a sovereign State and its capacities to steer society. Instead, it is about the relationships between a range of actors, technologies and processes usually including but not limited to the State, and how they act to manage 'the rules of the game in order to enhance the legitimacy of the public realm' (Kjaer 2004: 15). In the case of dioxins, it will become clear that government and industry have clearly been influential actors in the formation of risk assessment as a governance strategy. However, our understandings would be limited if we did not include the myriad other actors, relationships and processes that have also been formative regarding risk assessment.

For Abraham (1995: 18), risk assessment is a type of governance that was

> developed initially as a “scientistic” response by industry, especially the nuclear industry, to the perceptions of environmentalist and consumer movements in the 1960s that many industrial technologies posed undesirable and unacceptable risks to (certain sections of) society.

Similarly, Thornton (2000: vii) states that

> In the 1970s, industrialized countries adopted a framework for assessing and regulating toxic chemicals that remains in force today. This approach...the Risk Paradigm, attempts to manage individual pollutants using scientific and engineering tools, including risk assessment, toxicological testing, epidemiological investigations, pollution control devices, and waste disposal technologies.

Risk assessment can therefore be thought of as a set of techniques, ways and means that order and represent reality, in this case chemical realities, into calculable forms that allow them to be governed (Dean 1999b: 177). In situating the analysis of dioxins within understandings of the past emergence of risk assessment and governance, this approach acknowledges and takes as its starting point the unresolved past issues about dioxins and how they hinder closure for those who believe they have been affected.

In October 2001, the MOH contracted the Institute of Environmental Science and Research (ESR) to begin a study to assess the long-term exposure of residents to dioxins in Paritutu, the New Plymouth neighbourhood adjacent to the DowAgroSciences Ltd factory where 2,4,5-T had been produced. The study assessed dioxin levels by testing the blood of long-term residents (Baker et al. 2003; Fowles et al. 2005

; Read & Wright 2005). Before the research design was finalised, a period of local consultation was undertaken to ‘ensure that the plan reflect[ed] the needs and concerns of the affected residents and other key stakeholders’ (Baker et al. 2003: 1). Strongly alluding to the range of issues related to the past political and scientific contestation, the consultation report contains a list entitled ‘Concerns articulated, but largely historical and difficult to address through this study.’ Included is this list are ‘(a) Distrust of government, science and industry, (b) Allegations of conflict of interest in key stakeholders, (c) Government support of 2,4,5-T production...[and] (f) Disputed facts relating to historical events’ (Baker et al. 2003: 29). Most of these contentions about the past focus on the period during the early to mid 1970s when risk assessment strategies became prominent in the governance of dioxins. Thus, focusing on this historical evolution in New Zealand allows an insight into, and hopefully contributes to, a resolution, or at least a more complete understanding, of the disputed past and the power relationships it entails.

Thesis focus and research questions

The purpose of this thesis is to critically analyse the emergence of risk assessment as a governance strategy in New Zealand during the 1970s through a case study of the dioxin contaminant in the herbicide 2,4,5-T. Following poststructural insights into power, knowledge and discourse, risk assessment is conceptualised as embodying specific notions of truth and rationality that have arisen in a distinct period. It is therefore important to historicise governance by critically analysing how various forms of expertise inherent in risk assessment have attempted to rationalise themselves according to specific values of truth. Focusing on the discursive strategies that have legitimated such rationalities gives us insight into how emerging technological risks are constructed through various networks of power. Yet, this approach also allows an understanding of how power is subject to resistance and how the resulting tensions are differentiated geographically within a tangled, complex and messy web. Considering the above, this thesis addresses three main questions:

1. What are the discourses of human health, science and chemicals that have formed the contested narratives of risk assessment and dioxins?

2. How were these discourses constituted, sustained and made hegemonic by industry and government while simultaneously being challenged by social movements?

3. What role do the various scales of chemical politics (bodies, communities, environments and nations) have in the formation, legitimating and challenging of such discourses?

These questions are answered through an eclectic and interdisciplinary engagement with research from critical human geography, governmentality studies, environmental justice, science and technology and studies and medical and environmental sociology. The limited focus of much environmental justice and other research into chemicals pays inadequate attention to discursive strategies and power/knowledge relationships. This thesis argues that understanding the landscapes of environmental injustice and risk assessment requires mapping anew the power relations of chemical governance and a recognition that such processes are multidimensional and historically specific. Critically analysing these spaces opens up a new approach to understanding human–society–chemical interactions.

Methodology and theoretical approach

A sparse historical record, particularly at the government and industry level, has weakened previous work on New Zealand's dioxin history and resulted in several, widely cited, but largely uncritical accounts (for example see Brinkman 1986; Coster et al. 1986; Baker et al. 2003). To overcome this weakness, extensive MOH and District Health Board archival materials released under the Official Information Act (1981) were used to construct a more detailed narrative. Newspaper archives, chemical and agricultural industry journals and several activist collections of documents complemented the government archival materials as primary sources. An inductive methodology, guided primarily by a qualitative and discursive approach, was used to analyse these texts. These archival sources, despite their rich empirical value, contain numerous silences. Therefore, interviews were also conducted with citizens, activists, chemical industry employees and government officials to remedy, as far as possible, such silences and to generate ideas not apparent in the textual sources.

Thesis structure

The remainder of this thesis is divided into eight chapters. Chapter 2 outlines the theoretical framework that is used to answer the research questions and argues for a new approach to understanding environmental (in)justices. It moves away from local and structural accounts of inequality by suggesting that analysis should focus on conceiving of injustices as boundless, socio-historic and based on specific rationalities. Poststructural approaches to power/knowledge and governmentality are outlined and their usefulness in understanding how rationalities such as risk assessment are historically specific and based on distinct forms and technologies of calculation is discussed.

Chapter 3 describes the qualitative and inductive methodology utilised in this research. The accessing and use of textual materials through the Official Information Act and government and individual archives are discussed. The numerous silences that exist within the archives are also discussed, particularly in relation to how this research tried to make sense of, and was set within, volatile and active political spaces. My positioning as an activist researcher in these spaces is also discussed, in particular how this construction complicated the research process.

Chapter 4 discusses 2,4,5-T's discovery during the intense collaboration of science, government, academia and industry that occurred during Second World War. It discusses how the prominence of 'Big Science' during the post-war decades attained a hegemonic status through the dissemination of utopian discourses about science, progress and agrochemicals. The symbolic and material roles and influences of IWD are explored within a discussion about the company and their role in New Zealand's agrochemical revolution. The chapter argues that agrochemicals were represented as part of a 'chemical promise' to society that espoused how science and technology would herald unending social and material progress.

Chapter 5 explores how and when dioxins first began to be understood, and how part of our knowledge of this period is silenced by a lack of publicly available information. These silences are at least partly related to the connection of dioxin to the use of military defoliating chemicals by the United States during the Vietnam

War. The complex effects of this use, and their enduring politics and contestation, are discussed in relation to how they influenced the international and New Zealand emergence of risk assessment as a strategy of chemical governance. The central early discourse employed to govern dioxins, termed acceptable dose, is discussed. It is argued that while the chemical promise was being challenged, the authority and ability of science to control dioxins was reasserted through the acceptable dose discourse.

Chapter 6 continues to critique the acceptable dose discourse that had emerged around dioxins in the early 1970s. In 1972, New Zealand followed other countries and set a dioxin limit of 1 parts per million (ppm) in 2,4,5-T. This was lowered to 0.1 ppm in 1973. This chapter describes how these restrictions were uncritically rationalised using toxicology. While the uncertainties present in human–chemical interactions were evident, they were not publicly acknowledged by the New Zealand government or incorporated into the governance of dioxins. The chapter also explores the development of the technology to test minute dioxin levels in 2,4,5-T. While the improved ability to 'see' chemicals has been cited as one reason for increased anti-chemical sentiment during the 1970s, this chapter argues that it also allowed a perception of 'control' that reinforced the acceptable dose discourse.

Chapter 7 explores how the ability of epidemiology and toxicology to quantify dioxin exposures and link them to birth defects was incredibly limited, in part because of a lack of a systematised form of collecting birth defect data. The chapter also explores the wide-ranging voices of opposition that emerged against 2,4,5-T use in New Zealand, particularly with respect to birth defects. Such voices were narrowly characterised by the media, government and chemical industry as ‘emotional’ and ‘anti-science’. This section discusses how such opposition was actually extremely hybrid, consisting of scientists, doctors, politicians and citizens who were clearly articulating not anti-science, but instead more precautionary discourses that today are regarded as progressive.

Chapter 8 explores the IWD plant in New Plymouth that produced the majority of New Zealand’s 2,4,5-T and how the area represents a silence space of chemical contamination. It describes how the legislated limits on dioxins during the 1970s did not actually reduce the creation of dioxins, but just resulted in locally based wastes that were buried or incinerated in New Plymouth. The chapter briefly explores how the 1980s and 90s can be viewed as the ending of the chemical promise in New Zealand as the long-term effects of chemical use became evident. The unknown levels of dioxins in the mid-1960s 2,4,5-T and the high rate of birth defects in New Plymouth from 1964 to 1969 are discussed in light of their significance to contemporary complaints. The intense focus of government on resolving health disputes through the use of science is critiqued for how such a process narrowly defines the ways that chemicals affect society, and how such conceptualisations might ultimately contribute to continuing injustices.

Chapter 9 outlines the main ideas of the thesis and reflects on the implications of the findings. It argues that poststructural understandings of power, scale and discourse should be part of mainstream environmental justice research. Injustices, particularly those generated by boundless chemicals like dioxins should be understood as socio-historic, not just local expressions of structural inequalities.

Chapter 2: Reconceptualising environmental (in)justices through power/knowledge, discourse and the spatiality of science

This chapter outlines the conceptual and theoretical framework that is used to understand the history of 2,4,5-T and dioxins in New Zealand. First, the history and meaning of environmental (in)justices are explored. An approach that reconceptualises (in)justices as socio-historical phenomena that are composed of distinct rationalities and knowledge-making practices is then described. Second, poststructural human gegraphy, science and technology studies, actor-network theory and Foucauldian notions of governmentality, power/knowledge and discourse are outlined in relation to how they complement our understandings of the discursive strategies of risk assessment and dioxins.

Reconceptualising environmental (in)justices

Within academia, 'environmental justice' broadly refers to a range of methodological and theoretical approaches that study the impact of pollutants on society and how social groups tend to be differentially impacted (Agyeman 2002; Kurtz 2003; Williams 1999). The term also refers to various social movements that have sought to highlight and contest human exposure to such toxics (Bryant 2003; McGurty 1997). The use of environmental justice concepts in the theoretical framework presented here combines this social movement–academia nexus. As will be discussed in more detail in Chapter 3, a personal interest—one that is critical of dominant understandings of synthetic chemicals and their effects on society—was a central motivator in conducting this research. Thus, this thesis seeks to contribute to the environmental justice movement in so far as it critically analyses toxics in society. Additionally, as discussed next, it seeks to use, but also to reconceptualise, several theoretical insights from the environmental justice movement/literature.

As an interdisciplinary field of academic study, environmental justice includes contributions from geography, political science, demography, sociology and history (Szasz & Meuser 1997: 111). While an increasing body of international work is evident (Agyeman 2002; Agyeman et al. 2002), the dominant use and history of the term is associated with efforts in the United States to show that the negative effects of industrial pollution, and more broadly all environmental risks, are premised on inequality. Such analyses can crudely be broken into two associated areas of activism and academic inquiry (Kurtz 2003). *Distributional inequities* have been highlighted by mainly quantitative approaches that have stressed the spatially unequal aspects of waste emissions and their associated health impacts. Second, social science approaches have theorised environmental (in)justice primarily within a political economy framework that stresses structural aspects such as race, class and poverty as causative factors in *procedural inequities* (Weinberg 1998: 605). These foci originated with a series of studies in the US in the early 1980s (Bullard 1983; US General Accounting Office 1983; United Church of Christ 1987) that concluded that the racial and socio-economic status of citizens was a factor in the planning, building and general spatial distribution of hazardous waste facilities. African American and Hispanic American neighbourhoods, supposedly politically weak, are subject to disproportionate exposures to toxic emissions when compared with other socio-economic groups in society.

Building on Pellow (2002), Pellow and Brulle (2005) and Szasz and Mueser (1997), it is argued here that the distributional and procedural equity foci of much of the environmental justice literature limit our understanding of what counts as, and creates injustice. One criticism is that much environmental justice research is narrowly focused on discrete temporal and spatial occurrences of toxic pollution and its effects. Szasz and Mueser (1997: 107) note that while identifying spatial inequalities is important, 'such studies suffer from the same shortcomings: they document the relationship between social and toxic geographies at one moment in time. Even when serious inequities are found, such work is of little help in explaining *how it happened* [italics in original].' Similarly, sociologist David Pellow (in Callewaert 2002: 265) advocates that in order to fully understand the formation of environmental inequality one must redefine environmental inequality as a multi-dimensional socio-historical process rather than simply viewing it as a series of discrete events. Pellow stresses that research needs to describe the history and processes that have created environmental injustices and thus seek a greater understanding about the role of multiple stakeholders in both perpetrating and resisting injustices.

Further, much research into procedural inequities, even when looking beyond the local scale, has sought to analyse environmental injustices through narrow theoretical frameworks that view structural factors such as class and race having the most explanatory power (see for instance Heiman 1996; Hurley 1995). Pulido (1996) notes that this focus is in part because the environmental justice movement has originated in class- and race-based struggles that developed out of the US civil rights movements. While these efforts should be respected, and acknowledgment should be made of the fact that the class and race focus has resulted in positive fundamental changes for many disenfranchised communities, such a focus has limited the kinds of questions that environmental justice research has asked about toxics and society (Szasz & Meuser 1997). For instance, Beck (1992: 13) has noted that synthetic chemicals are 'supra-national and non-class specific' because of their ability to transcend spatial and temporal boundaries. This is not to suggest that within certain spatial boundaries chemicals do not regularly affect specific social groups in more profound ways. However, their boundlessness suggests that other, non-structural and non-local ways of understanding them may broaden our understanding of their production, dissemination and effects.

Considering these criticisms, what constitutes an environmental injustice and how we understand them can be reconceptualised. Following Roberts & Toffolon-Weiss (2001: 11), this thesis utilises the broad perspective that environmental injustices occur whenever a person or persons are impinged upon by an environmental burden for the alleged good of society that the rest of society does not bear. Such a perspective retains the notion of environmental inequality that has been stressed within most environmental justice research and activism. However, it argues that some injustices may not be temporally or spatially discrete, but can instead be messy and complex, affecting different places and people differently throughout time (Taylor 2000). Understanding injustices requires a focus on not just describing their occurrence, but on trying to understand how they develop in the first place through a complex series of socio-historic interactions.

Many aspects of toxic pollution and its effects on society have their origins in the governance strategies of risk assessment. Toxics are created, managed and disseminated through a series of technologies and calculative rationalities that attempt to control the risks such substances pose. Therefore, this thesis argues that understanding these rationalities, knowledge-making practices and discursive strategies that support governance strategies such as risk assessment, can open up a new and crucial area of environmental justice research.

Human geography, governmentality and governance: situating power/knowledge within risk assessment

Human geography and expert knowledge

This section outlines the contribution that recent approaches to human geography can make to understanding dioxins and risk assessment. For human geographers, the production and circulation of knowledge is inherently spatial. By examining the geographies of knowledge, attention is focused on 'how different kinds of knowledge are co-constituted through particular places, embodied practices and technological artefacts' (Davies *et al*. 2004: 293). Following postmodern critiques of Enlightenment approaches to truth and knowledge, human geography has approached these geographies of knowledge from several important perspectives.

First, there has been the recognition that social life is inherently messy, complex and unstable. Thus, many traditional theoretical approaches that stress a coherence and fundamental ordering to the social world are being disavowed in favour of understandings that more effectively convey the disorder and dynamic character of society (Cloke et al. 1991). Second, the notion that objectivity is possible in social theory has been challenged by the recognition that all knowledge is situated, that is, knowledge is always constructed from a position somewhere in society (Haraway 1991). Part of the situatedeness of knowledge is the recognition that knowledge production and dissemination is rife with relationships of power. Additionally, knowledge is not permanent because the contexts within which knowledge is produced and circulated are unstable and ever-changing. As Thrift (1996: 41) notes, context should be regarded as ‘a plural event, which is more or less spatially extensive and more or less temporally specific.’

Third, human geography has in the past, and to an extent still is, marked by a preoccupation with binary thinking, highlighted by a focus in scholarship and teaching on dualistic categories such as nature/human, urban/rural, economic/cultural and qualitative/quantitative (Cloke & Johnston 2005). Much theorising since the 1990s has sought to interrogate these polarised categories in favour of *hybrid* understandings that seek a more complex and representative conceptualisation of society.

A key feature of this shift has been an increased concern with relationalism, broadly defined as the relationship between social processes and spatial processes, or ‘spatially situated interactions’ (Murdoch 2006: 3). While relational thinking has always been a foci of geographical scholarship, the traditional divide within the academy has been for human geographers to study social relations and for physical geographers to investigate physical relations. Poststructural approaches in particular have sought to overturn this ontological divide between society and nature by highlighting how spatial formations are heterogeneous in their make-up (Massey 1999). A focus on heterogeneity emphasises that all relations are inevitably composed of natural and social, and human and non-human interactions (Murdoch 2006). Thus poststructuralism ‘recognises agency as a relational achievement, involving the creative presence of organic beings, technological devices and discursive codes, as well as people, in the fabrics of everyday living’ (Whatmore 1999: 26).

Part of reconceptualising the human/nature binary through a focus on relationalism and heterogeneity has been a period of sustained debate within human geography about two key spatial terms: space and scale, or what Kurtz (2003: 888) has termed the 'problem of spatial scale.' Increasingly human geographers are concerned with challenging the position of scale and space as fixed categories.

Like the conventional views of power that are discussed in the next section, traditional perspectives on scale regard categories like local, regional, national and international/global as fixed and territorially bounded configurations, often in relation to the State. In this view, scale is often conceptualised as a preordained framework that operates from the top down and/or from the bottom between discreet and fixed local, regional and global spaces. Marston et al. (2005: 417) describe this as the hierarchal approach where scale is regarded as a 'nested hierarchy of differentially sized and bounded spaces.' Thus, the ability to govern through rational practices is constructed as a series of linear flows, usually through a preordered movement of ideas and authority. Likewise, space has often been defined within human geography as the fixed container in which social relations occur. Agnew (2005: 81) notes that 'terrestrial space is often understood as the plane on which events and objects are located at particular places.'

Human geographers have argued that it is more useful to consider scale and space as social constructions, rather than as an 'ontological pre-given[s]' (Delaney & Leitner 1997: 93; Marston 2000). Scale is thus an epistemology, a way of trying to know and understand the world (Jones 1998). Similarly, space is not a fixed container; it is being made relationally, or as Murdoch (2005: 23) notes,

> spaces are made of complex sets of relations so that any spatial solidity must be seen as an accomplishment, something that has to be achieved in the face of flux and instability. Space is made relationally. This means that space and place have no determining structure; rather structure is an effect of relations.

This perspective allows a recognition that different spaces and scales are at various times themselves implicated in the production of social, economic and political processes realities, and vice versa. As Herod (1991) notes, they are simultaneously socially produced and socially producing.

Following Bulkeley (2005), the theoretical approach taken in this thesis is that scalar hierarchies, if they exist, are not the result of bounded territorial categories like local, national and global. Instead such hierarchies are always contested, are fluid and are composed of relations that work across and between scales, which allow the domination and subjugation of certain scales, at discrete times. Thus, the delimitation of scale as discrete units needs to be replaced by a focus on the 'processes through which particular scales and scalar relations come to be constructed and engaged in particular projects of governing…rather than labouring under the assumption that such territories are necessarily contiguous, bounded and homogenous' (Bulkeley 2005: 897).

Foucault, power/knowledge and expertise

This section outlines Foucauldian notions of governmentality, power and knowledge and how such perspectives allow an insightful critique of risk assessment. Following Foucault & Deleuze (1977), theory is conceptualised here as a toolbox, and like Rose (1998), Foucault's ideas are regarded as useful, but tentative, starting points. Such an approach does not pledge an unequivocal allegiance to Foucault's ideas but instead uses several general concepts to help to frame the ‘ethos of enquiry’ (Rose 1998: 5) employed in the following chapters. Therefore Foucault’s ideas are more an invitation to do further research and less a set of definitive conclusions (Simons 1995: 40).

In Chapter 1 governance was defined as the relationships between a range of actors, technologies and processes, usually including but not limited to the State, that coalesce to direct human conduct. The conceptual framework articulated here is broadly situated within understandings of governmentality that can be thought of as the foundations upon which the authority of governance is enacted. Governmentality thus stresses the importance of examining the history of truths, ideas, and systems of thought and their construction within specific modes or forms of rule such as risk assessment. Such an approach highlights how the activity of thought is inextricably bound up with the activity of governing and that the production of truth and knowledge is intertwined with the exercise of power (Rose 1998: 8). This approach allows us to do a ‘political history of the production of “truth” ’ (Mills 2003: 74).

For Foucault, governing can be understood as the ‘conduct of conduct,’ meaning the deliberate and calculative means that attempt to influence and direct human conduct. Dean (1999a: 11) describes the ‘conduct of conduct’ as

> any more or less calculated and rational activity, undertaken by a multiplicity of authorities and agencies, employing a variety of techniques and forms of knowledge, that seeks to shape conduct by working through our desires, aspirations, interests and beliefs, for definite but shifting ends and with a diverse set of relatively unpredictable consequences, effects and outcomes.

This perspective on governing, one where the direction of human conduct is regulated and shaped by rationalities and knowledges, contrasts with traditional notions of power, rule and government. The conventional—or what Scott (2001: 6) calls the 'mainstream'—view of power, uses as its exemplar the sovereign power of the State. Here, a finite entity, agent or institution holds power and wields it over other institutions, groups and individuals. This perspective tends to conceptualise power as a material 'thing' that is held and that equates only to domination and command (Sharp et al. 2000: 2). Foucault (1972, 1978, 1980) instead argues that power is more like a verb than a noun. Power is not a thing or a possession held by an entity or imposed by a structure, but is instead the product of social relations and is performed and enacted strategically in particular local contexts (Mills 2003: 35). Power is thus productive as well as coercive, and the structures, concepts and ideas that constitute society are not ideal types, but are constantly being made and remade (McHoul & Grace 1997: 64). Foucault (1977: 194, emphasis added) notes that

> We must cease once and for all to describe the effects of power in negative terms: it "excludes", it "represses", it "censors", it "abstracts"...In fact, power produces; it *produces* reality; it produces domains of objects and rituals of truth.

Thinking of power as the outcome of social relations, not as a thing held and imposed, allows for a reconceptualisation of the importance of resistance. In most structural and liberal accounts of power, domination and resistance are finite groupings that are analysed in isolation from each other. It is useful instead to employ a more hybrid notion of domination and resistance. Following Sharp et al (2000: 20), domination and resistance are understood here as thoroughly entangled, where each cannot exist independent of the other, but 'neither can they be reducible to one other'. Thus all moments of domination are composed of relations of resistance and vice versa. While certain individuals or institutions might for various reasons have more access to resources that allow domination, seeds and acts of resistance are always present.

Based on such a view of power and resistance, a key aspect of Foucault's idea of governmentality is that governing has increasingly taken place beyond the formal State apparatus. Sovereign powers of command that mark the mainstream view of power have been superseded by 'disciplinary power'. Scott (2001: 95) notes that 'In its most general meaning, discipline is the control that is exercised over people through systems of rules that are not simply imposed on them but are instilled in them.' Disciplinary power thus 'forms individuals with the motives, desires, and orientations that enable them to act as properly formed members of the governed social groups' (Scott 2001: 94). In this sense, government recognises the capacity of the populace to act, and instead of crushing this capacity, it is used to govern (Rose 1998: 4).

The crucial aspect of Foucault's disciplinary power for the conceptual framework utilised here is that it has arisen and is dependent on systems of expertise. Numerous bodies of specialist and technical knowledge have emerged with the growth of modern liberal government—law, accounting, medicine, psychiatry, and, as argued in the following chapters, risk assessment. Such expertise attempts to rationalise itself according to specific values of truth. These systems of knowledge encourage 'the building of trust on the part of the lay majority in the expert minority' and act to discipline the populace (Scott 2001: 93). Knowledge and power are thus imbricated and inseparable. In *Discipline and Punishment*, Foucault (1977: 27) writes that

> power produces knowledge...power and knowledge directly imply one another...there is no power relation without the correlative constitution of a

> field of knowledge, nor any knowledge that does not presuppose and constitute at the same time power relations.

Within a governmentality approach, it is important to analyse how expertise contributes to knowledge's gaining the status of truths. For Foucault, analysing the truths themselves is less important than examining the *conditions* that allowed certain types of knowledges to become regarded as truths. Revealing such conditions allows us 'to expose the *political and strategic nature* of those ensembles of knowledge previously thought to be either relatively independent of power...or linked only in a vague or inadequate way to political institutions' (McHoul & Grace 1997: 60). Dean and Hindess (1998: 9) refer to these ensembles of knowledge as the 'mentalities of government' or 'the forms of reasoning related to the exercise of authority'.

The importance that a governmentality approach puts on specific social, historical, spatial and political conditions that are necessary for knowledge/power relationships is useful for understanding the rise of risk assessment as a form of chemical governance. Foucault argues that relations of power/knowledge have historical specificity, arising in distinct periods where governing is called into question. Dean and Hindess (1998: 8) describe these moments as 'problematisations' that 'appear in definite social, institutional or professional locales and can be assigned a time and place'. This view of government is therefore not grounded in normative and universal principles of political thought and power but instead looks to specific practices and locales to explain how knowledges are constructed as true or false (McHoul & Grace 1997: 65). Power is spatialised and for Foucault this means that analysing power 'should be concerned with power at its extremities, in its ultimate destinations, with those points where it becomes capillary, that is, in its more regional and local forms and institutions' (Gordon 1980:

96). Thus in describing and understanding the emergence of risk assessment, it is useful to employ a governmentality approach that analyses

> what counts as truth, who has the power to define the truth, the role of different authorities of truth, and the epistemological, institutional and technical conditions for the production and circulation of truth (Rose 1998: 30).

Power/knowledge and discourse

Poststructural insights into power and knowledge focus on the political and strategic nature of certain forms of knowledge. As such, knowledge is the result of power struggles and is a fundamental way the physical and social world is ordered for improved management and control (Foucault 1978). For Foucault the concept of 'discourse' and its analysis are of primary importance in understanding this power/knowledge nexus. Foucault (1980 in McHoul & Grace 1997: 59) notes that

> relations of power cannot themselves be established, consolidated nor implemented without the production, accumulation, circulation and functioning of a discourse. There can be no possible exercise of power without a certain economy of discourses of truth which operates through and on the basis of this association.

Discourses are sets of sanctioned statements that have an institutionalised force that influence how individuals and societies think and act (Mills 1997: 62). In this sense, communicative language (whether verbal, textual or visual) is a site of production and contestation. Similarly, discourses do not transparently reflect reality, but instead they actively construct and organise our social realities (Tonkiss in Hoggart et al. 2002: 163).

Thinking of discourse as a system of language that both socialises and is socialised allows insight into how certain systems of knowledge, such as risk assessment and science, have become hegemonic. Mills (1997: 26) explains that discourses are

> those groupings of statements which have similar force—that is they are grouped together because of some institutional pressure, because of a similarity of provenance or context, or because they act in a similar way…[Foucauldian discourse analysis] is less interested in statements in and of themselves than in the way they coalesce into discourses or discursive formations and take some of their force from such groupings.

Employing this type of discourse analysis means focusing less on the actual linguistic elements of an utterance and instead stresses examining the rules and structures that allow the production of some texts and discourses, while excluding others. Foucault described such an analysis as 'archaeological' and described the rules and structures that govern discourse production as the 'conditions of possibility'. These conditions both constrain and enable how we represent the world, and they are not haphazard, but instead they are particular to specific temporal, spatial and cultural settings (O'Farrell 2005: 79).

Articulating these notions of exclusion and limitation is important in discourse analysis. Some discourses survive, get re-used and command authority, while others are repressed, censured or publicly ridiculed. Foucault (in Mills 1997: 51) notes that discourses are characterised by a 'delimitation of a field of objects, the definition of a legitimate perspective for the agent of knowledge, and the fixing of norms for the elaboration of concepts or theories'. Thus, only certain discourses are considered 'real' and can be employed only by certain actors who construct how and in what form such discourses will endure. Discourse analysis therefore seeks to uncover and make apparent these exclusions, and maps the power/knowledge relationships they entail.

Two specific types of exclusionary practices that will be useful in examining the discourses of dioxin and risk assessment are *commentary* and the *academic discipline*. Commentary refers to the processes and constraints whereby texts are kept in circulation. To be elevated to 'truth' status, discourses representing certain knowledge must be commented on, discussed and debated. Canonical phrases, ideas or references that are widely employed and discussed strengthen certain discourses, while those not circulated are minimised. Similarly, academic disciplines work to determine within their own domains what can count as truth. These structures allow new ideas to be articulated, but only within limited discursive bounds closely guarded by the discipline. While counter ideas may exist, disciplinary boundaries tend, according to Foucault, to exclude new propositions more than they enable (Mills 1997: 69).

Two other aspects of Foucauldian discourse analysis are relevant here. First is that the formation, articulation and continuation of discourses do not follow a linear path but instead are characterised by discontinuities, gaps and ruptures. Discourses are not stable, but are always changing, shifting and lurching in odd ways that maybe hard to pin down and decipher. These disjunctures, sometimes large and apparent, but often small and seemingly trivial, are central to discursive formation and should be elevated and examined, not reduced (Smart 2002: 50).

Related, is the notion that despite the hegemonic standing certain discourses command, their instability provides spaces of resistance. As truths are not transcendental, discourses are in constant conflict with other discourses as societies work to produce and defend certain ideas. Discourse analysis seeks to reveal the limits that systems of thought and institutional practices entail and to break down these oppressive claims to universal truth (O'Farrell 2005: 61). Thus, understanding how certain ways of thinking and knowing become regarded as truths opens up room to think about how things might have been otherwise. As Foucault (1978: 100–101) stated:

> We must make allowances for the complex and unstable process whereby discourses can be both an instrument and an effect of power, but also a hindrance, a stumbling block, a point of resistance and a starting point for an opposing strategy. Discourse transmits and produces power; it reinforces it, but also undermines it and exposes it, renders it fragile and makes it possible to thwart it.

Science and technology studies and actor-network theory

This section builds on the ideas of relationalism and heterogeneity previously outlined and discusses how science and technology studies (STS) and actor-network theory (ANT) encourage a focus on how geographic locations are aligned through their networked connections.

Science and technology studies (ST&S) is an interdisciplinary field merging the work of geographers, sociologists, anthropologists and historians in order to study the 'processes and outcomes of science and technology' (Sismondo 2004: vi). A broad feature of STS scholarship is the interrogation of the ideas, concepts, beliefs and categories that are encapsulated in the relationship between science and technology and society (Kleinman 2005).

Kleinman (2005) identifies two broad foci of the STS literature that are relevant for understanding issues of governance, power and expertise discussed in this thesis. First, is the critique of *scientism*, or the popular image of science as value-free and politically neutral. Accordingly, facts are distinct from values and facts 'are superior in terms of credibility and cognitive authority (Kleinman 2005: 4). Second, is the idea of *technological progressivism* that is rooted in Enlightenment thinking and suggests that progress, informed by technology, is a synonym for social good. Technological development becomes taken for granted and is self-propelled, moving along a singular and positive trajectory.

STS has sought to challenge scientism and technological progressivism foremost by highlighting the social and political character of science. This has been done through a diverse range of epistemological and ontological positions. One approach that has highlighted the heterogeneous character of science and technology, or technoscience, is actor-network theory (ANT). Articulated mostly forcefully by Michael Callon (Callon and Latour 1992), John Law (Hassard & Law 1999) and Bruno Latour (1988), ANT proposes that technoscience involves processes of heterogeneous construction where the material and social worlds are simultaneously shaped to construct networks that in turn create order. This view rejects the idea that science is built on layers of accuracy obtained from objective and direct observations of the world. Instead, the power of science rests 'in its ability to control and manipulate elements, both human and natural, in ways that allow scientific facts to be built and then disseminated beyond the centres of scientific practice' (Murdoch 2006: 57).

The actors of ANT (termed actants) are heterogeneous in that they include both human and non-human agents, with no distinction or innate hierarchy between them. ANT is thus about how actants, distant in space, are able to be enrolled, mobilized and situated in certain types of conduct and relationships. Whatmore (1999: 28) defines an actor network as

> simultaneously an assemblage of actants, whose activities are constituted in and through their connectivities with heterogeneous others, and a network that performs as a more or less durable (extensive in time) and more or less long (extensive in space) mode of ordering amongst its constituent parts.

ANT builds on the situated and relational notions of space and scale discussed earlier by demonstrating how locally situated practices and rationalities can move, intact, to other places. Regarding technoscience products and practices, Sismondo (2004: 67) notes that

> science and technology must work by translating material actions and forces from one form into another. Universal scientific knowledge is the product of the manipulation of local accounts, a product that can be transported to a wide variety of new local circumstances. It is only applicable through a new set of manipulations that adapt it once again to those local circumstances (or adapt those local circumstances to it).

One of Bruno Latour's early statements on ANT, *The Pasteurization of France* (1988), demonstrates how scientific ideas are made through heterogeneous connections and are remade and consolidated while moving between different places. Latour argues that scientists do not simply observe nature, but they actively construct nature using a range of technological, social and cultural assumptions and tools (Murdoch 2006). Latour does this by demonstrating how Pasteur successfully transferred the laboratory conditions under which he had been studying anthrax bacillus out into the field, in this case a farm. By completing a successful trial of the vaccine at a specified farm, Pasteur demonstrated that what was once only possible under laboratory conditions, the prevention of anthrax, could be accomplished on a farm, and in society generally. In doing so, society is transformed by the microbes as they become legitimate actors who are actively constructing social relations. Latour thus demonstrates how power emanates from the ability of differently situated actors to be tied together outside the lab, enabling scientific facts to travel intact and colonize society in diverse ways.

Two specific ideas, *immutable mobiles* and *centres of calculation*, are useful for understanding how networks are able to strengthen themselves via processes between a scientific centre of authority and a locale. Murdoch (2006: 64) defines a centre of calculation as 'a discrete space able to act effectively on many other dispersed spaces.' Latour argues that immutable mobiles are material artefacts that act as delegates that not only carry facts and other rationalities from centres of calculation, but they also act to carry aspects of the local back to the centre. Immutable mobiles allow ideas to be transported from place to place without changing form. This allows networks to become durable, enhancing and hardening the connections that keep them intact.

Manufactured uncertainty and the risk society

The previous section described how a poststructural approach to power/knowledge can interrogate the rationalities and knowledge-making practices that support various governance strategies. This section begins to outline how the unique hazards, or risks, that chemicals pose have fundamentally altered our abilities to understand—and thus control—them within such frameworks of rationality. The work of sociologist Ulrich

Beck is informative because it demonstrates how the useful industrial products of science paradoxically transcend the abilities and logic of science, and in doing so politicise the knowledge used to govern chemicals.

Ulrich Beck (1992, 1995) has been the leading proponent of the 'risk society' thesis where environmental degradation and risk are positioned as central facets of modern society. His research has examined the macro-structural factors responsible for this shift and has compared the present risk society with what he considers to be different epochs of the past. While in previous periods risk was associated more with random dangers, modern risks are understood primarily as a human responsibility, both in their production and their management. Government, industry and science are singled out in much of this analysis as both the primary producers and managers of risk (Lupton 1999: 4).

Notwithstanding criticism of Beck's work as overly structural, too generalised and lacking in empirical weight (Dean 1999b: 135), notions of risk society are useful for understanding the governance of dioxin through risk assessment. First, Beck's *Risk Society* (1992) and *Ecological Politics in an Age of Risk* (1995) specifically address how industrial risks such as synthetic chemicals undermine but also reinforce existing safety systems and methods of rationality based on calculation. Second, the ability of these risks to seemingly escape the logic of control upon which modern governance is based has profound implications for how society judges and reacts to chemicals such as dioxins.

For Beck, the past epoch of 'industrial society' was marked by risks that could be spatially and temporally limited. For instance, the air pollution from a steel mill might have substantial effects on local inhabitants, but such hazards did not threaten entire populations or the planet as a whole. Conversely, modern risks such as nuclear power and dioxins know no boundaries in time and space. When released from a factory or as the result of combustion processes, dioxin molecules can travel on global air currents and be deposited thousands of miles from the site of their production (Thornton 2000). In a temporal sense, dioxins are incredibly stable, resisting natural breakdown processes and accumulating in soil and the fatty tissues of living organisms.

Beck (1992) and Giddens (1991, 1995) refer to this ability of risks such as dioxin to escape from their point of origin and interact within the environment in unknown and uncontrollable ways, as 'manufactured uncertainty'. For Beck, a related and distinctive feature of modern environmental risks is their 'social invisibility'. Without spatial and temporal origins or limits, colourless and odourless molecules such as dioxin render risk immaterial. These risks thus elude the conventional imagination and become 'untrackable to everyday perception' (Goldblatt 1996: 159).

Faced with such uncertainty and invisibility, the rules of causality and guilt that frame much chemical regulation are broken down in the risk society. Adam et al. (2000: 6) highlight how the uncertainties inherent in manufactured risks challenge conventional modes of governance and rationality:

> Effects of the prized 'foreign bodies' suffuse our earth in uneven intensity, the resulting hazards dispersed not only over space but also time. Innovative, disembodied technologies whose impacts are temporally and spatially unbounded, yet affect some areas and beings more than others, render traditional assumptions about planning and managing the future inappropriate and consequently the language of prediction and control loses its pertinence.

In Beck's analysis, this loss of rational control over risks has resulted in several distinct relationships between society and the rational practices, such as science, that seek to govern them. First, the immateriality and invisibility of risks mean that they are made real and material primarily through scientific and cultural contestation (Goldblatt 1996: 159). This contestation generates multiple claims of authority within society where the fragility of science is revealed and yet sometimes reinforced. Risks therefore involve a politics of expertise and counter-expertise. Second, the technical difficulties and limitations of science in measuring complex risks such as dioxins are a primary element that generates these debates. Without 'certain' knowledge, the regulatory process and the ability of governments to communicate effectively to society are challenged. This contestation and uncertainty generate a politics of knowledge where the potential for political influence on the scientific process is increased and, as was suggested in Chapter 1, normalised. For Beck such features have led to the process of 'organised irresponsibility', which

> denotes a concatenation of cultural and institutional mechanisms by which political and economic elites effectively mask the origins and consequences of the catastrophic risks and dangers of late industrialisation. (Goldblatt 1996: 166)

Within risk societies a paradox exists where degradation occurs unabated despite increased regulatory control and oversight. Responsibility is not directed at specific individuals or organisations that are responsible for the production of risks, but is instead consumed by the 'legal, epistemological and cultural matrix in which environmental politics is conducted' (Goldblatt 1996: 166). Beck describes this matrix as the *relations of definition*, which are the specific rules, institutions and capacities that structure how we identify and analyse environmental problems. Goldblatt suggests these relations are contested and centre on at least four key questions that contemporary risks pose to governing:

> (1) Who is to determine the harmfulness of products or the danger of risks? Is the responsibility on those who generate those risks, those benefiting from them, those affected...or public agencies? (2) To whom does the proof have to be submitted? Who...are the proper arbiters of risk assessment and who should have to defend or interrogate those claims? (3) What is to count as sufficient proof?...What are the grounds...for accepting or rejecting different claims about risks and hazards? (4) Who is to decide on compensation for the afflicted and appropriate forms of future control and regulations?

Beck's risk society thesis thus opens a useful conceptual space for thinking about risk assessment, one where practices of rationality are increasingly relied on to make technical decisions, but where paradoxically they struggle with the complexity of such risks. However, it is important to note that utilising a theoretical approach that incorporates both Beck and Foucauldian and poststructural approaches as outlined previously, is difficult (Lupton 1999). Beck's characterisation of risk as a *structural* condition that represents a seemingly clean shift from one epoch (late modernity) to another (risk society) is in many ways the antithesis of a governmentality orientation that disavows totalising approaches. Governmentality research has demonstrated that while risk may be a feature of society, treating it as singular logic does not necessarily help to reveal the everyday practices of science and technology. As Van Loon (2002: 45) has noted, Beck's macro orientation has 'swept many of the intricacies of technological culture under the carpet of generalist sociological assumptions.'

While the compatibility of utilising ideas from Beck and Foucault is clearly fraught with difficulties, each approach provides useful insights for the other (Van Loon 2002). Similarly, Lupton (1999) suggests that too little attention has been given to merging insights from the risk society and governmentality perspectives. In particular, she notes that each approach tends to operate at the level of a grand theory, while lacking empirical detail about how risk is perceived and put into action in everyday life. Thus, this thesis utilises Beck only insofar as his conceptualisation of chemicals, particularly in *Ecological Politics in an Age of Risk,* broadly outlines that the movement of synthetic molecules between different spaces and scales is a fruitful area of research into how risk assessment practices, and their scientific rationalities, are made and remade. However, poststructural approaches to power, knowledge and discourse allow a more nuanced picture of risk assessment to emerge.

Conclusions

This chapter has argued that environmental (in)justice research needs to examine the discursive construction of power/knowledge practices as they relate to human–chemical–society interactions, particularly the use of risk assessment as a governance strategy. Such an approach recognises that toxic pollution often manifests itself locally. However, within a poststructural framework, power is conceptualised as fluid and is made and resisted in part through practices of rationality that transcend the local. Massey (1994) argues that while certain activities or rationalities are ‘place-based’, this does not mean they are place-bound.

This chapter has outlined how conceptualising space and place as defined containers where the ability to govern through rational practices is constructed as a series of linear flows, usually through a hierarchical or horizontal movement of ideas and authority is insufficient. In trying to understand the rationality practices that govern dioxins, it is more useful to consider scale as a social construction, rather than as an ‘ontological pre-given’ (Delaney & Leitner 1997: 93; Marston 2000). Scale is thus an epistemology, a way of trying to know and understand the world (Jones 1998). This allows a recognition that different spaces and scales are at various times themselves implicated in the production of social, economic and political processes realities, and vice versa, or as Herod (1991) notes, scale is simultaneously socially produced and socially producing.

In his book *Rule of Experts*, Timothy Mitchell (2002) examines a range of technoscientific practices and rationalities that contribute to the formation of the twentieth century Egyptian state. He argues that many features of modern rule, for instance, the rule of property, gain their power insofar as they are able to appear as universal abstractions and inherent conceptual structures, with no trace of their particularity and history. Tracing the forms and sites of calculation and the movement of such knowledges as they are translated, simplified and redrawn are an important task for social theory (Mitchell 2002: 116).

Thus, the perspectives on scale, power and knowledge outlined in this chapter are necessary when considering the myriad of actors (dioxin molecules, chemical industry, government, social movements) discussed in Chapter 1 that are involved in chemical politics. The following chapters argue that understanding the discursive construction of dioxins by these actors is not fixed in time, nor is it fixed in space, but can be understood only through a recognition that rationalities are made real through complex interactions between different scales.

Chapter 3: Archival methodologies and silences within an active political space

This chapter describes the methodological framework employed in the remaining chapters. It focuses on the discursive nature of textual materials and how such materials, despite numerous silences, allow an insight into the power/knowledge character of dioxins and risk assessment. The first section describes how the available textual materials about 2,4,5-T and dioxins were able to be assembled from a range of sources and how they represent a distinct archive. The second section critically explores the gaps, or silences, in this archive of textual materials and discusses the use of coding to organise and analayse the data. The third section reflects on the research process and the realities of doing politically active research.

Accessing the archives of dioxin governance

The poststructural insights into power and knowledge discussed in Chapter 2 focused on the political and strategic nature of certain forms of knowledge. Discourse is one approach that allows us to interrogate these power/knowledge relationships, because discourses are sets of sanctioned statements that have an institutionalised force that influences how individuals and societies think and act (Mills 1997: 62). In order to assess the discourses of dioxins, a wide variety of documentary material, supplemented by interviews, has been used.

In the original thesis proposal, interview material was to serve as the primary textual data. Thus, during the first six to nine months of research, interviews began with citizens in New Plymouth, the details of which are explained later. In this early interview process I met a range of people, termed 'activists' from here on, who considered themselves part of a social movement seeking recognition for dioxin and human health issues. During these interviews, and in particular during long periods of casual conversation with activists in-person, on the phone and through email, I became aware that a key point of contention for the social movements focused on dioxins is the lack of historical understanding regarding how the chemical was governed during the 1950s to1970s (Chapter 1). This was also made clear when activists showed me the paucity of government and industry documents they had in their own personal collections of documents, or what I am calling 'activist collections'. In total there were approximately 20 to 30 documents covering the 1960s to 1980s in these activist collections: several from Ivon Watkins-Dow (IWD) and Dow USA; several from the Taranaki District Health Board (TDHB) which replaced the Department of Health (DOH) local offices following government restructuring; and the remainder from the Ministry of Health (MOH) which replaced the DOH. These experiences, along with the successful acquisition of a large volume of government archival material (explained next), resulted in a methodological shift towards utilising almost entirely documentary data.

The textual data that could be assembled are grouped into five main categories:

- unpublished government records;
- published government materials;

- commercially published sources (industry, popular media, journals);
- public interest/non-governmental organisation materials; and
- interview transcripts.

Within each of these categories, the sources of the materials and the means used to access them varied widely (Table 1). The following describes these specifics for each category and comments on how the research process affected the accessing and use of them.

Table 1 Type, source, location and means used to access textual materials (location of activist collections withheld to maintain confidentiality). See also Appendix 1 and 2 for full list of government file series

Type	Source	Location	Means used to access
Department of Health(DOH)/Ministry of Health (MOH) unpublished records	MOH file series (see Appendix 1 for full list) Activist collections	National Archives, Wellington	Official Information Act (1982) Open public access Restricted-access files via MOH permission Research visit
Agricultural Chemicals Board unpublished records	Pesticide Board file series (see Appendix 1 for full list) Activist collections	Offices of the Agricultural Chemicals and Veterinary Medicines Group of the New Zealand Food Safety Authority	Pre-arranged research visit Research visit
Taranaki District Health Board (TDHB) unpublished records	TDHB file series (see Appendix 1 for full list) Activist collections	TDHB main office, New Plymouth	Pre-arranged research visit Research visit
New Plymouth District Council (NPDC) unpublished records	NPDC file series (see Appendix 1 for full list) Activist collections	NPDC office, New Plymouth	Pre-arranged research visit Research visit
Published government materials	MOH file series (see Appendix 1 for full list) Public library holdings Activist collections	National Archives, Wellington Assorted New Zealand public libraries	Open public access Research visit Research visit
Service: A Journal of Agricultural and Chemical Progress	Landcare Library	Landcare Library, Lincoln	Research visit Interloan
Other commercially published sources (industry, popular media, journals)	National Archives, Wellington Public library holdings Activist collections		Research visit Research visit Research visit
Public interest/non-governmental organisation materials	Public library holdings Activist collections	Assorted New Zealand public libraries	Research visit Research visit
Interview transcripts	Interviewees	Throughout New Zealand	Pre-arranged research visit

Unpublished government records obtained through the Official Information Act and National Archives

The primary unpublished government records found in these sources are: internal correspondence within and between government agencies; correspondence between government and the chemical industry, primarily IWD; and correspondence between government and the public, including citizens, medical professionals, unions and various public-interest groups. Unpublished government records were obtained from two archival sources. As previously noted, personal collections of documents held by several activists provided a small quantity of government and industry documents, including several not found in other sources. However, official government archives became the main source of documentary materials.

The process of gaining access to unpublished government records via official archives was an interesting, convoluted and ultimately, political process. As noted earlier, the original thesis proposal entailed relying on contemporary interview materials and it later shifted to documentary sources when it was recognised there was a need for historical research. When this occurred, my understanding of archival sources and how they were accessed was limited. However, I noticed that most of the small activist collection of government documents had been stamped 'Released as Official Information Under the (1982) New Zealand Official Information Act.'

The Official Information Act (OIA) was passed into law in 1982 and replaced the Official Secrecy Act (1951). The guiding principle of the OIA is that government information must be made publicly available unless good reason exists for withholding it (Ministry of Justice [MOJ] 2007). The Act parallels similar reform enacted in many Western liberal democracies that has sought to promote more effective public participation in government and to reduce government secrecy. As such, the OIA can be thought of as an instrument of resistance insofar as it allows largely open access to evidence of discursive strategies normally ‘hidden’ from public view. However, as will be discussed in the second section, numerous gaps or silences exist in government archives that limit the effectiveness of the OIA in disrupting and resisting dominant narratives.

With little to no knowledge about how government archival systems operated, I decided to use the Official Information Act to access historical information about 2,4,5-T and dioxins. This process was started by deciding how and whom to contact to submit a request. This was done primarily through researching material publicly available at the websites of the Office of the Ombudsman (http://www.ombudsmen.govt.nz/internal. asp?cat=100017, accessed May 2007) and the MOJ (http://www.justice.govt.nz /pamphlets/2001 /info_act.html, accessed May 2007).

The OIA stipulates that requests should be as focused as possible, usually citing specific documents or a narrow range of files within a designated file series. However, advice from several colleagues with experience in using the OIA, one a dioxin activist and the other a past researcher for a New Zealand political party, was that a broad and general request might be more useful. This was based on the premise that it is better to start broad, and that such a request might elicit a more open response from the MOH to engage with my research. I therefore submitted a written request for the release of official information to the MOH in July 2003.

The response from the MOH was positive and was followed by negotiations via email about how my request could proceed considering its broad nature. The result of these negotiations was that the MOH allowed reviewing of an extensive range of DOH files at their Head Office in Wellington (MOHW). Over the course of three research visits, files were reviewed, notes were taken and documents to be formally requested under the OIA were flagged. An agreement was reached with the MOHW that they would release, where allowed under the OIA, the requested documents and waive the considerable processing and photocopying expenses on the condition that they were provided with a copy of the finished thesis. In total, approximately 2200 pages of documents were released under the OIA by the MOHW, primarily from the 340/3/138 & 156/11/48 file series (Appendix 1). A similar process of conducting a research visit and then viewing, flagging and having documents released as Official Information was undertaken with the TDHB in late 2003. This resulted in approximately 200 pages of documents being released.

Subsequent to these Official Information requests and my research visits to MOHW, I learned that most of the viewed MOH files (but not the TDHB files) were publicly available with no restrictions at the National Archives, Wellington (NAW). Thus to an extent the use of the OIA was unnecessary as these files could have been viewed at the NAW without consulting the MOH. On the surface this is part of the learning process that research entails as I was unaware of the workings of the archival systems of government. However, it is revealing to the extent that when I made my large and open request to the MOH initially, they did not choose to inform me that these files were available at the NAW, but instead engaged me in the OIA process. This engagement is likely a reflection of the active political space that dioxin issues have had in New Zealand during the research process. The Ministry appears at least partly committed within such spaces to facilitate research into past dioxin governance in recognition that unresolved historical issues hinder a resolution of contemporary grievances (Chapters 1 & 8).

Practically, the public availability of these files at NAW allowed a reviewing and further reading of the MOH file series and facilitated the further discovery of relevant file series. Three important files of the 156/11/48/1 series, covering almost two years during the 1970s, which had not been provided during research visits at MOHW were located at NAW: 47146, 47934 and 49070. Several restricted files containing birth defects records were also found at NAW which had not been part of the MOHW OIA requests. Permission to view these files at NAW was granted by the MOH. In addition, a range of other relevant file series was found at NAW. While most of these other series are not as important as the 340/3/138 & 156/11/48 series regarding dioxin, they still provide important textual data (see Appendix 1 for complete list of accessed file series).

Confusingly, the previous discussion about using the OIA while the files are publicly available at NAW applies only to the MOH files. The TDHB files, and those of many of the other government agencies (described next) whose archives were drawn on, do not store their files at NAW, but instead have their own internal archival systems.

Unpublished government records obtained outside the OIA via informal requests

Additional unpublished government records were obtained via sources besides the OIA and NAW. Following the successes of using the OIA with the MOH and the TDHB, a similar approach was made to the New Plymouth District Council (NPDC) and to the Agricultural Chemicals and Veterinary Medicines Group of the New Zealand Food Safety Authority (ACVM/NZFSA). IWD has been accountable to the NPDC for wastewater emissions, and NPDC has had a general involvement in public matters regarding the plant since the 1960s. The ACVM/NZFSA is the government agency responsible for the former Agricultural Chemicals Board (ACB) files (see Appendix 2 for complete list of files searched at ACVM/NZFSA). It was created by the Agricultural Compounds and Veterinary Medicines (ACVM) Act (1997) as part of widespread New Zealand government restructuring. The ACB was a quango created by the 1956 Pesticides Act and was responsible for the registering, labelling and monitoring of pesticides.

Both the NPDC and the ACVM/NZFSA allowed unrestricted access to files, which were viewed in their offices during research visits. As with the TDHB records, the files of these agencies are not held at NAW. NPDC files are held on-site at their New Plymouth offices, while ACVM/NZFSA files are stored off-site at a warehouse that houses the main collection of Ministry of Agriculture archives (J. Reeves, ACVM/NZFSA, personal communication, 5 Dec. 2004).

For reasons not explicitly stated, both agencies chose to handle these requests outside of the Official Information Act process on a more informal basis. Similar to experiences with the MOH and TDHB, requested documents were flagged, notes were allowed to be taken and agency employees photocopied all flagged documents. However, unlike the OIA releases (see next section on silences), no NPDC or ACVM/NZFSA documents were withheld or redacted (subjected to intentional deletions), nor was an official letter stating the documents were being released under the OIA provided. While not ever stated explicitly, these agencies appeared to view the OIA process as burdensome and unnecessary. For instance, an ACVM/NZFSA official (J. Reeves, ACVM/NZFSA, personal communication, 5 Dec. 2004) noted in an email prior to a research visit that he would strive to

> save [me] the trouble of formally seeking...document[s] via the OIA. If there is any doubt in my mind, then we would ask you to formally request it, but I should be able to make the decision easily and most things could be released, I am sure!

Conversely, a formal explanation for why the MOH strictly followed the OIA was never sought. However, one suspicion is that because of the prominent public involvement the MOH had at the time, including ongoing work on major studies (Baker et al. 2003; Fowles 2005), and widespread media coverage, they chose to be more cautious.

Finally, the Ministry for the Environment (MFE), the Ministry of Agriculture and Forestry (MAF) and the Taranaki Regional Council (TRC) all hold unpublished files relating to New Plymouth air pollution, DowAgroSciences NZ Ltd, dioxins and 2,4,5-T. The widespread restructuring of New Zealand government agencies during the 1980s and 1990s has resulted in additional layers of complexity regarding who is responsible for past records, which limits the effectiveness and accessibility of the official State archival system. For instance, the DOH/MOH was until 1991 responsible for air pollution regulations. These responsibilities now reside with regional councils. Thus, there is a chance that some historical DOH files could be in regional council archives and future researchers might find it beneficial to explore these file series. However, because of the richness of the archival material obtained from other government agencies, time and expense limitations, and the largely ‘modern’ (post 1990s) composition of their files, MFE, MAF and TRC files were not researched.

Published government materials

Between 1970 and 2007, over 30 different official government reports have been published relating to dioxins and 2,4,5-T. The MOH occasionally publishes 'Organochlorines Research in New Zealand: A Bibliography' (www.moh.govt.nz.phi), which provides a comprehensive listing of these government reports. Most of the post-1990 reports were obtained directly from the respective government agency, while all pre-1990 reports were viewed either at public libraries or within the 340/3/138 & 156/11/48 file series at NAW. Also utilised were numerous public reports produced by other governments worldwide who dealt with similar dioxin and 2,4,5-T controversies. All of these reports and references to them are found in the 340/3/138 and 156/11/48 file series. German, UK, Swedish, Australian and US reports from 1969 to 1987 form the bulk of these published government studies contained in MOH files.

Commercial publications

This category includes all materials produced about 2,4,5-T and dioxins not published by government, including: news media (film & print), industry public relations materials, scientific reports, popular books and agricultural and industry journals. News media assisted greatly in assessing how various discourses were constructed publicly, and their publications contain useful information on times, dates, places and names of important actors. News media were accessed via three sources. The MOH file series, particularly 156/11/48/1, has news clippings arranged chronologically for most key dioxin events post-1970. *The Taranaki Daily News*, a local New Plymouth newspaper, has a handwritten index from 1976 to 1989 and near-complete referencing of noteworthy local dioxin and 2,4,5-T events is found under the 'Air Pollution' category.

This index was also useful for providing date ranges of key events, which were subsequently searched for in other New Zealand newspapers via microfiche. Finally, two activists allowed use of their largely complete newspaper cutting collections, which cover New Plymouth and Wellington newspapers between 1999 and 2006.

Chemical industry public-relations materials addressing dioxin and 2,4,5-T have been produced since 1970. Usually in the form of a pamphlet or 'fact sheet', these texts represent, among other things, industry discourses that highlight how other actors (government, activists, citizens) are constructed by industry. The majority of such New Zealand materials were produced by IWD and are available chronologically in the 156/11/48/1 MOH file series.

Agricultural and chemical industry journals provide an excellent source of written and visual textual materials. *The New Zealand Journal of Agriculture* (*NZJA*) and the IWD publication *Service: A Review of Agricultural and Chemical Progress* were the primary texts utilised. Both these sources provide a range of primarily pro-industry editorials, opinion pieces and general articles that deal with dioxins and 2,4,5-T and the controversies that surround them. While the *NZJA* is a prominent journal, *Service* is a largely forgotten IWD publication that was published from 1957 to 1973 and was aimed primarily at farmers. A nearly complete collection is housed at the library of Landcare and was accessed via interloan. While not well known, *Service* is an extremely valuable archive of IWD company and product history, and of discursive materials in the form of opinion pieces, advertising images and reprinted overseas articles (Chapter 4). A similar chemical industry journal is *Dow Diamond*, produced by Dow Chemicals USA between 1937 and 1971, and *Seed World*, a USA agricultural supply magazine. These were accessed at the National Agricultural Library, Beltsville, Maryland, USA.

Public interest/nongovernmental organisation publications

Since 1970 a range of individuals and groups have sought to highlight environmental, social and human health concerns regarding dioxins and other chemicals. These have included international organisations such as Greenpeace, national groups in New Zealand such as the Environmental Defence Society and local-level groups such Residents Against Dioxins and the Dioxin Investigation Network. These groups were identified through their presence in other archival materials, (particularly popular material) and through their own correspondences contained in unpublished government files. Published materials from these groups were obtained from the groups themselves and consisted primarily of 'fact sheet' publications and also general correspondence.

Interview material

Interview material was gathered at two distinct phases of the research, however as will be discussed later, this material did not contribute significantly to the issues presented in this thesis. First, approximately 15 interviews were carried out in the beginning of the research. These interviews were with citizens who thought their health was affected by exposure to dioxins, former IWD employees and dioxin activists. The majority of these interviews were conducted in New Plymouth. They were semi-structured interviews where participants were asked a schedule of questions to glean specific information, but were also encouraged to take the interview in other directions.

As discussed previously, the original thesis proposal was designed around using interview transcripts as the primary textual data. Therefore, my initial access to potential interviewees was through a loose coalition of activists, mostly in New

Plymouth, who are engaged in social movements around dioxins and human health. I noticed the most prominent group, at the time known as the Dioxin Investigation Network, in newspaper articles, and made my initial contact through their spokesperson. These activists simultaneously gave me 'insider' access to a vast network of people in New Plymouth, and acted as 'gatekeepers' through initially determining to an extent whom I got to meet. This positioning was partially mediated by numerous frank and open discussions, usually initiated by the activists, about 'what sort of people' I wanted to interview. Thus, while they undoubtedly regarded some interviewees as more critical for me to meet, they were also open to my desire to talk to a wide range of people. Such discussions do not eliminate the influence that interviewees identified through activists may have on the research, but acknowledging this positioning highlight the practicalities of accessing interviewees, particularly within an active political space (see final section, this chapter).

The second round of interviews occurred towards the end of the research in an attempt to build on my developing research findings and because my potential pool of interviewees had grown markedly over several years of research. Interviewees included medical personnel involved in dioxin controversies, Vietnam veterans and activists, most of whom lived outside New Plymouth. Finally, I was contacted on numerous occasions via phone and email, and in person, by from individuals who wanted to tell their dioxin and 2,4,5-T stories. The active media attention and conduct of several major government studies during the time of this research, my contact with activists in New Plymouth, participation in email discussion lists and media appearances positioned me as an outlet for a range of actors concerning dioxins. While these interactions were not interviews in the formal sense, they contributed substantially to the research by way of cross-referencing information and providing new directions.

Ultimately, the transcript materials from these interviews did not contribute significantly to the thesis. In select cases, information obtained in the interviews did act to confirm discrete historical facts that were alluded to in the government and newspaper archives. However, many interviewees either were focused on the contemporary issues of illness in New Plymouth or had specific historical accounts about dioxins that eventually did not become topics upon which the thesis focused.

Deconstructing the archive and paying attention to silences

This section examines how the textual materials and the archive they constitute were analysed, and discusses the gaps, or silences, that exist. Following post-structural critiques of objectivity, this research was approached from the perspective that there is no 'right' way to organise and analyse material. Instead, as Hannam (2002: 189) suggests, analysis provides a thorough and convincing reading of data, yet leaves open the possibility that others might assemble and read the same data differently. All research is conducted from specific positionalities that entail different and unstable beliefs and values. Sorting and dealing with data thus becomes subjective and creative and is not fixed, but instead constantly changes during the research process, based in part on new findings (Crang 1997).

Within this framework, the discourse analysis methodology consisted primarily of coding and recoding of the gathered textual materials. This process began with open coding, where data were organised into smaller and more discrete groupings based on the thematic categories that emerged. These categories were then examined and compared for similarities and differences, and coded again. Attention was focused on the processes of *intertextuality*, which is how texts refer to other texts and build on or contradict each other. Intertextuality thus helps identify the moments that power is enacted and strengthened, but also may reveal the contingent and unstable character of power. This process of coding, recoding and building thematic categories was not fixed to one phase of the research, but was enacted throughout. Thus, archives reveal how various discourse of dioxins, health and risk assessment were formulated and articulated, and how they were differentiated between contexts (public, private) and actors (government, industry, citizens).

Silences

Geoffrey Tweedale in his book on the history of the asbestos industry comments that the 'darker side of industrialisation' is often not covered in business histories. This is partly because, as he says, 'To be sure, historians in these areas face the problem of finding archive material, as in the so-called "dangerous trades" the records are rarely available' (2000: ix). If such materials are unearthed, it is almost always through court proceedings. Such 'discovery' processes are the primary way that existing critical histories have been written about lead, tobacco, vinyl chloride and asbestos (Brodeur 1985; Castleman 1984; Markowitz & Rosner 2000, 2002; Miller 1999; Ozonoff 1988; When 1995).

In the case of dioxins, the textual materials that have been used provide widespread and in-depth coverage into many aspects of the chemical's history over time. However, this archive of textual material is neither complete nor without significant gaps and omissions. Hannam (2002: 194) notes that we should detail these interruptions and disruptions to the otherwise smooth flow of documents. In doing so, we should question why silences occur. That is, why are certain topics, documents or file series missing and/or shallow, and why have deletions and omissions occurred?

An obvious silence within the data-set is the minimal representation of materials illustrating counter-hegemonic perspectives. In the 1960s and 1970s, anti-chemical sentiment was just emerging as a counter-discourse to rational explanations of health and dioxin exposure (Chapters 5, 6 & 7). While letters from concerned citizens and medical staff are well represented in the MOH file series, published materials from nongovernmental organisations and dissenting opinions in newspapers and journals are sparse. Thus, documentary data can tend to be biased towards hegemonic discourses because these dominant voices will inevitably be more thoroughly represented and documented.

While valuable, the use of the OIA does create silences through regulations that allow certain intentional deletions, or redactions, before documents can be released publicly. Regulations of the OIA that restrict access to information were used by the MOH and resulted in numerous redactions. These were:

- Section 9(2)(a), which provides that names and addresses of natural persons be protected;
- Sections 6(a) and 6(b), which protect the confidence of foreign governments;
- Sections 9(2)(b)(ii), which provides for the protection of commercially sensitive materials; and

- Section 9(2)(h), which maintains legal privilege and therefore precludes most Crown Law Office documents from being released.

Interestingly, while these restrictions were extensively employed by the MOH, the TDHB in its released documents did not apply any redactions, notably those possible under Section 9(2)(a). In addition, the MOH chose in several instances to withhold documents for reasons not explicitly covered under the OIA, including their desire to discuss documents with their originators as a 'matter of courtesy'. However, these documents were eventually released. Thus, while the OIA is covered by specific rules and criteria, these are interpreted in a purposeful fashion that differs across government departments. This points to how various government departments are situated differentially in the production of power. Considering the contentious nature of the dioxin debate and the active political space it has occupied during the research process, the MOH, for example, obviously felt more inclined to fully subscribe to the OIA, perhaps because of the sensitivity of the issue. Conversely, other agencies might have felt they were in a less tenuous position in relation to the issue and thus were willing to be pragmatic with the OIA.

Some of the noted silences created by the OIA have been overcome by simply sighting the redacted MOH content at NAW. Thus, while intending to preserve certain vestiges of information restriction, OIA redactions are largely redundant if the same documents are publicly available in other places. However, the same cannot be said for the accessing of files, such as those of the NPDC, TDHB and ACB that are not held in public archives. While these agencies were generous in letting files be accessed and copied at their offices, conducting archival research under such circumstances is ultimately constrained. For instance, the opportunities to revisit such files to read them anew or to later cross-reference newly discovered information is limited compared with in a public archival system, and this creates a silence.

Time is another element that may contribute to silences in textual material. The majority of unpublished government files that formed the core of the textual data were from the period 1965 to 1990. Over a period of 15 to 40 years, documents may be destroyed, misplaced or lost and this can create silences. The Health Protection and Principal Health Protection Officer at the TDHB informed me that several 'important' files regarding dioxins had been inadvertently destroyed in the early 2000s during routine file maintenance. At the very least, this is indicative of how poor archival practices can create silences. Additionally, officials at both MOHW and TDHB made comments to the effect that their files are 'well worn because they have been accessed so many times'. Referring to the cycle of controversy that has surrounded dioxins in New Zealand, this regular accessing of historic files that might otherwise reside in secured archives is a potential cause of missing documents and files.

The final silences discussed are the omissions, deletions and gaps that may be intentional. Thiesmeyere (2003) notes that some silences are the results of deliberate actions where the social and political character of materials is regarded as unbeneficial to certain interests. The considerable controversy, both internationally and in New Zealand, that has surrounded dioxin politics has resulted in accusations that files have been tampered with, that fraud has occurred, that data have been manipulated and that the government and the chemical industry have withheld vital information from the public (Baker et al. 2003; Chapters 5 & 8). Several instances encountered during the research process support these findings.

For instance, the period 1960 to 1970 represents perhaps the most contentious period of dioxin history because of high dioxin levels in 2,4,5-T and the purported incidents of birth defects. In a point explored in more detail in Chapter 5, this period is also undoubtedly the most silenced, because of a lack of publicly available records, particularly from the chemical industry. In New Zealand, much of the contentious nature of this period surrounds the reportedly significant (Brinkman 1986; Baker et al. 2003), but unexplained dioxin emissions from IWD in New Plymouth between 1964 and 1969. Documents detailing the numerous complaints about air pollution from IWD in 1964 are contained in the 340/3/138 & 156/11/48 file series. However, less than 12 documents detailing how these complaints were addressed over a four-year period were found in the archival record. Further, less than ten other documents appear to exist in these otherwise rich file series for the entire 1965 to late-1969 period. No files addressing this period are available from the TDHB.

In the 340/3/138 & 156/11/48 file series a significant number of 1960 to 1987 letters from IWD to government departments (primarily MOH) are missing. While an initiating or replying letter from government exists, the ‘sister’ letters from IWD are not in the files. Thus, the internal industry discourses and their construction of certain key events are not well represented in some portions of the 340/3/138 & 156/11/48 file series. While it is unclear why this silence exists, a pattern is clear and it suggests a structured exclusion of industry documentation from government files. One possibility that is hinted at, but only in a minority of cases, is that commercially sensitive IWD information was sent to the DOH, but then was required to be returned to the company.

A significant silence also exists internationally for the 1960 to 1970 period. Only several dozen chemical industry documents, released in the United States during 1983 court proceedings, exist publicly worldwide with regard to the existence of dioxins, how they were measured, and in what concentrations they existed in products and in factory emissions during the 1960s. Similarly, while testimony referring to this period has been made by industry executives (US Senate 1970), limited documentary evidence exists to substantiate the claims made during these hearings. This self-imposed silence by the chemical industry of basic historical documentation, government neglect in seeking this information and the possible purging of archived files, create a substantial gap in the archive, leading to substantial gaps in our understandings of dioxins (Chapter 8). In seeking to redress these silences, DowAgroSciences NZ Ltd was contacted on two occasions and asked whether they would be willing to participate in the research by producing documents and commenting on past issues. On both occasions this opportunity was declined by the company (Appendix 3).

Reflecting on research in a politically active space

Poststructuralist critiques of positivist knowledge as objective, value-free and impartial (Valentine 2002) are followed here, and the situated aspects of this research are reflected upon. Understanding knowledge as situated means recognising that all knowledge is produced in specific embodied contexts and circumstances (Haraway 1991). These multiple influences position how we approach our research, what we find and how we interpret our findings and thus challenge notions of 'objectivity' and 'neutrality' (Rose 1997).

Understanding the situated nature of knowledge and our positionalities necessitates a reflexive approach to research, where it is important to clearly articulate our own positions in order to overcome false notions of neutrality. However, as Valentine (in Moss 2006: 126) has pointed out, it is impossible to fully identify a complete, transparent and knowable self and instead

> our focus should…be on looking at the tensions, conflicts and unexpected occurrences which emerge in the research process…By exploring these moments we might begin to decenter our research assumptions, and question the certainties that slip in the way we produce knowledge.

The focus of this research has been on the past, particularly the 1970s. However, the *processes* of researching and writing has been conducted in a contemporary political and social climate where these issues of the past have been very intertwined with the present. In this section I explain how this current space of controversy, coupled with my own positionality, influenced how I approached researching the past and also how I was positioned by those involved in these contemporary political spaces.

Positionality

To interrogate my postionality, I begin by briefly outlining my background. I am a naturalised New Zealand citizen, having moved to New Zealand from the USA in 1999. At times being 'from America' was useful, as many participants in the dioxin controversy viewed 'outside' interest as less biased and more objective as they see much New Zealand participation as being tainted by a long history of denial. However, my hybrid status as an American, but also a New Zealand citizen who has lived in country long enough to understand the cultural norms and general national psyche, positioned me usefully as both an insider and an outsider.

My undergraduate studies in environmental policy included a strong critical component that has influenced the direction of this research. My undergraduate supervisor, Professor Michael Heiman (Dickinson College) is a prominent US environmental justice advocate who widely influenced how I view inequality, social relations and the politics of pollution. The focus of many courses in our Environmental Studies department revolved around environmental justice issues and included numerous field trips to waste management facilities like incinerators and hazardous waste sites, and to nuclear power plants. These studies built on a strong awareness of how large-scale industry can cause widespread social and environmental change, brought about by my growing up in Pittsburgh, Pennsylvania, a former steel and coal centre of the US industrial revolution. At the time of this writing, I see myself as a part of the anti-toxics and environmental health movements that seek to critically examine how modern production processes affect human health. This position 'within the movement' was tentative before beginning this research, but as will be discussed later, has become more committed over the last five years.

Contested and politically active spaces

As discussed in Chapters 1 and 8, since the 1990s, issues of human and environmental dioxin contamination have become prominent issues in New Zealand. In particular, since 1999, New Plymouth dioxin contamination has become contested by local activism, leading to increased media and government attention. As a result, several major studies have been conducted between 1999 and 2007 and dozens of widely covered media pieces have been published. Accusations, deepening mistrust and suspicion between dioxin affected citizens and the government have created a volatile political and social issue. Thus, the conduct of my research has occurred in this dynamic and conflicted space. Being positioned in what I term a ‘politically active space’ has resulted in several research related aspects worth reflecting upon.

The main emotion that this politically active space was marked by was fear and paranoia. In New Plymouth in particular, I encountered many instances where people were hesitant to talk about dioxin issues. If open to talking, our exchanges were often constrained in several ways. Some interviewees would not agree to talk unless a local activist was present. Some interviewees did not want me coming to their homes and preferred to meet in public, while others preferred to use a ‘neutral’ friend’s house. During interviews some participants would visibly tense up when I got out a tape recorder. This led me to regularly not use a tape recorder and instead to rely on handwritten notes. Even then, I noticed with some participants a significant shortening of their answers and more hesitancy when I would begin to take notes. Other people declined to be interviewed because they indicated they feared unspecified personal or professional recrimination, while others cited instances of promised confidentiality being breached in past interviews. Besides interviews, some people were reticent to talk on the phone, telling me they preferred to communicate in person because they believed their phones were tapped or because they had heard about other people who had experienced phone tapping and other forms of suspected surveillance.

The results of these interactions on the research were twofold. First, I began to be cautious about how I communicated in general. Secondly, not feeling I was able to communicate openly with several people led to a more introverted approach to the research during several periods as I hesitated to telephone several activists with frequent questions, instead ‘saving up’ the questions to discuss when I saw them next in person. Whether the concerns were based on real threats or on paranoia, or a combination of both, these interactions led to feelings of being under surveillance or at least involved with others who might be experiencing surveillance.

Collaboration

From the beginning of this research I worked closely with a network of activists who are working towards resolving issues of dioxin injustice in New Zealand. I initially contacted several activists in New Plymouth in order to facilitate finding potential interviewees. What evolved over the following five years is a fruitful relationship that has resulted in what I now see as a collaborative role in their efforts. Aspects of this collaboration include the sharing of information with various activist groups, providing informal editorial comment on materials they produce and offering advice on possible strategic directions.

Participatory research is a recent trend in social sciences research that seeks from the onset of research to actively work with community groups to help them solve problems (Pellow & Brulle 2005). My collaboration however was not originally in this vein and instead the decision to actively participate in working with activists evolved slowly. Initially I did not position myself or even consciously think I would 'become part of' the more general dioxin social movement underway. While I was compassionate to the activists' perspectives, I took the disembodied idea that I was open to a range of research issues and was therefore separate and outside them. The activists themselves did nothing to actively dissuade me from this position. Repeatedly they pushed me to adopt my own perspective on the issue, noting that they would assist me with any information they could. I sense they believed that whatever perspective I adopted regarding the issue it would be beneficial, as so little historical work has been done on dioxins in New Zealand.

While I began to feel more aligned with their goals, I sought to not come across as being part of 'the movement' while conducting research outside the activist group, for instance in my dealings with government. Sometimes I found myself consciously trying to adopt an objective academic stance because I knew it would give me better access. Conversely, at other times I unconsciously wore a more 'activist' mask to gain access. Such pragmatism was often uncomfortable, yet it did help me negotiate the politically active space within which this research was conducted.

Conclusions

This chapter has described the archive of textual materials concerning 2,4,5-T and dioxins that was able to be assembled from a range of sources. Significant silences exist in this archive and were created in numerous ways, including the Official Information Act, possible intentional deletions, lack of availability of chemical industry files and the nuances of government archival practices. The conduct of this research occurred in a politically active space where contemporary grievances about dioxins and human health are to an extent underpinned by contested understandings of the past (Chapter 1). Despite the silences, the archive of textual materials available create a space where we can begin to critically interrogate the past constructions of chemicals and health and their relevance to contemporary debates.

Chapter 4: The progressive discourses of Big Science and the chemical promise

The public controversy and governance of dioxins did not begin internationally and in New Zealand until late 1969, when Agent Orange use in the Vietnam War and new research indicating that dioxin in 2,4,5-T might cause birth defects initiated widespread debate. However, much of the resultant governance strategy of risk assessment, which is discussed in later chapters, is centred on notions of science, both as an institution and as a form of rational knowledge. In foregrounding these ideas, this chapter examines the social contexts and discourses of science that precluded and constituted the conditions of possibility that allowed the emergence of risk assessment. The chapter does this by examining the early history of 2,4,5-T, both internationally and in New Zealand. It argues that the period 1940s to 1960s was marked by unique relationships between science, government and industry that were discursively constructed through a 'chemical promise' to society.

The chapter is divided into four sections. The first section outlines how the period immediately before and after the Second World War altered the relationships between science and society in unprecedented ways. The second section suggests how the use and discursive construction of 2,4,5-T are usefully understood within a broader post-War revolution in agrochemicals that occurred within New Zealand's agricultural economy. The third section discusses how the purported ability of 2,4,5-T to transform agricultural practice was actually tempered initially by discourses of scientific caution. The final section outlines the importance of the New Zealand chemical company Ivon

Watkins-Dow (IWD). It describes both its leadership in 2,4,5-T production and manufacture, and how it normalised agrochemical use through utopian discourses of progress.

Big Science

Science is often popularly conceptualised as an activity bestowed with mythical powers that exists separate from society. In such an idealist view, science is regarded as a formal activity where specific methods are used to discover and accumulate knowledge about the natural and social world. Science is objective, remaining divorced from value judgements and striving for consistency; different scientists considering similar evidence would arrive at similar conclusions (Sismondo 2004: 1). Using rigorous methodologies, scientists are able to produce pure truths about the world. Such truths form the basis for Western notions of knowledge and are often constructed in binary opposition to intuition, common sense and values that are disregarded as ways of 'knowing' (Bauchspies et al. 2006: 5). This divide between facts and values is what Kleinman (2005: 4) refers to as *scientism*, where facts 'are superior to values in terms of credibility and cognitive authority'.

A range of literature has demonstrated that far from being an objective and value-free pathway to knowledge, science is foremost a social construction and a social process (Bloor 1976; Kuhn 1962; Latour & Woolgar 1979). Wing (2000: 40) notes that:

> The basis of the critique of value-free objectivity is simple: it is impossible to know the world without intellectual tools, including languages and socially produced concepts. Whether explicit or not, all scientific investigations depend on conceptual frameworks. There can be no unmediated experience.

Livingstone (1995, 2003) notes that thinking about science as socially constructed entails a recognition that it is also thoroughly geographical. That is, science is not an eternal essence ‘floating transcendent and disembodied above the messiness of human affairs (Livingstone 2003: 179), but is instead a social practice that is always situated in time and space. Thus, in seeking to understand how dioxins and other synthetic chemicals became governed by risk assessment in the 1970s (Chapters 5–7), it is useful to critically examine the situated character of the post-Second World War scientific enterprise.

The second half of the twentieth century can be viewed as a period when science and rational knowledge became politically and culturally important in unprecedented ways (Yearley 1988). Adam et al. have noted that this period was marked by the increased prominence of ‘Big Science’. In their view (2000: 17), such science

> refers to the intensive involvement of capital. Big Science is characterised by large amounts of incoming economic capital, for example in the form of government funds and business sponsorships as well as high amounts of political, social and symbolic capital. These forms of capital grant authority, status and significance to scientific projects...Big refers to the prominence and prestige accredited to particular scientific programmes which tend to negate questions of legitimation and social impact.

The period immediately before and after the Second World War was highly influential in the maturation of Big Science (Abraham 1995; Bauchspies et al. 2006; Jasanoff 2004). While the State had intervened in many ways to promulgate science before the War, it was only during this period that it took on a decidedly ‘organized and institutionalised form’ (Salomon 1977: 45). The sheer volume of productive capacity needed to sustain the war effort, and the belief by both sides that a technological breakthrough would win the war led to unprecedented levels of expenditure on science.

Following the end of hostilities, science became a key driver of capitalist expansion, as the productive capacity and innovations of wartime were transferred into civilian uses.

Big Science also became an important form of political capital. Innovation and advancements in science and technology became regarded as defining characteristics of military and thus geopolitical strength (Lakoff 1977). As Hogg (1964: 11) noted, ‘A nation’s power to prosper in peace, survive in war, and command the respect of its neighbours, depend[ed] largely on its degree of scientific and technological advance.’ Governments thus engaged in ‘collective measures taken...in order, *on the one hand*, to encourage the development of scientific and technical research and, *on the other*, to exploit the results of this research for general political objectives’ (Salomon 1977: 45–46, emphasis in original). These efforts were marked by much closer links between government, industry and academia, which became ‘more inventive, intense and self-perpetuating’ than in previous decades (Pickstone 2000: 14).

Big Science and the chemical industry

The chemical industry is perhaps the exemplar of Big Science in the twentieth century. Like the mining industry, the chemical industry provides the basic building-block materials for almost all other industries and thus is often referred to as the ‘industry’s industry’ (Grant et al. 1988: 3). This vital economic role is matched by the notion that the chemical industry was the vanguard of what Pickering (1992: 15) has termed ‘technoscientific companies’, or those industries that blur the line between pure and applied research. With enormous laboratories and research centres, the chemical industry's internal research and development complex positioned them as the dominant 'knowledge based' industry in the post-War period (Arora et al. 1998: 6).

Part of this technoscientific complex was borne out of the war effort, as the chemical industry both altered the outcome and was itself altered by the pressures of war. During the 1920s and '30s, several technological breakthroughs had begun to transform the industry, the most influential being the shift towards using petroleum and natural gas as primary feedstock instead of coal tar (Campbell et al. 1991). The scale of wartime productive capacity and short-term investment in capital works enhanced this shift. Within the US, Germany and the UK, the traditional centres of the chemical industry, funding for chemical science research also increased and was geared towards discovering technologies that might help one side win the War.

The chemical industry is also a useful example of how the political, economic and cultural capital of science altered society after the War. The unwavering optimism in economic rationality and progress during the post-War period was demonstrated perhaps most clearly by the chemical industry's dazzling array of new products and technological innovations that began reaching consumer markets as soon as the war ended. Plastics, synthetic fabrics such as nylon, household cleaners and a range of revolutionary agricultural chemicals were all the results of wartime research programmes that spilled into domestic lives. In many ways, the chemical industry typified 'science's promise to an affluent society. The arrangement seemed too good to alter, its assumptions too fundamental to question, its rewards too consistent for anyone to call too loudly for change' (Kinnane 2002: 168). Similarly, Crone (1986: 3) notes that the wondrous nature of chemical products was supported by a feeling that typified what this chapter argues was a *chemical promise*, that 'science would now assist in the creation of a new, socially just and technically advanced society'.

Phenoxy herbicides and New Zealand's agrochemical/grasslands revolution

A specific area in which this chemical promise was evident is in the early history of 2,4,5-T during the 1940s to 1960s. The chemical promise to society would be promulgated in New Zealand by the importance that post-War chemicals would have on agriculture. This section begins by reviewing the initial discovery of 2,4,5-T as a product of Big Science.

The focus of the dioxin controversy has been on 2,4,5-T; however, it is useful to consider the wider group of weedkillers of which 2,4,5-T was a part. Known as the phenoxy or hormone weedkillers, this group includes 2,4,5-T, MCPA (4-chloro-*o*-tolyloxyacetic acid) and 2,4-D. While 2,4,5-T had high levels of dioxins, 2,4-D contained unknown but definitely lower levels (particularly non-TCDD dioxins) and did not garner attention from governing authorities until the early 1980s (see Appendix 4 for details). Today, 2,4,5-T manufacture and use is banned in most countries, although restricted use is allowed in several nations. However MCPA and 2,4-D use is still widespread, with 2,4-D being the top ranked-herbicide (in pounds applied) within the US home/garden, industrial and commercial markets (Robbins & Sharp 2003), and internationally it is one of the most widely used agricultural chemicals.

Since the early 1900s, botanists had been aware of numerous naturally occurring chemical agents in plants that retarded and promoted growth. By 1940, a large number of these hormones had been identified and were being synthesised and tested for potential horticultural and agricultural applications (Troyer 2001). However, the discovery of phenoxy weedkillers was facilitated by the intensive academic, government and military collaboration during the Second World War. Chemical weapons, including herbicides, were being actively investigated as part of the war effort and thus ‘an era of shotgun experimentation on the effects of chemicals on plant growth’ with hormonal agents was undertaken (Troyer 2001: 291). One result of this was the discovery and formulation of phenoxy chemicals. Their chemical structure was found to be effective at simulating a range of natural plant hormones, particularly those that caused plants to grow. Thus, the herbicidal action of phenoxies was that sprayed plants would initiate a phase of uncontrolled growth, causing widespread cell proliferation that killed the plant.

Phenoxy chemicals appear to be have been discovered simultaneously in several places. Most histories of this discovery do not account for the complex scientific relationships that the War entailed, and instead uncritically give credit to either the US (Bovey 1980; Institute of Medicine 1994) or Britain (Blaxter & Robertson 1995; Lockhart et al. 1982). More likely is that several research teams in both the US and the UK synthesised phenoxies within several years of each other. This is supported by Troyer (2001: 290), who has shown that in the case of 2,4-D, a ‘quadruple independent discovery’ occurred between 1941 and 1943 at Imperial Chemical Industries (UK), Rothamsted Agricultural Experiment Station (UK), the American Chemical Paint Company (US) and the University of Chicago/Beltsville Experimental Station (US). Strict wartime secrecy banned publication of such discoveries in scientific journals and curtailed communication between organisations. In addition, the promise of civilian agricultural applications, and hence the corporate trade secret potential of a lucrative product, likely resulted in the lack of initial sharing of these discoveries, even amongst allies.

However, the scientists at the University of Chicago were contracted to the US Army and so they began to study phenoxies for two military uses in the Pacific war zone: Japanese crop destruction and jungle clearance. In the beginning of the Allied campaign in 1943, large amounts of high explosives were being used to deny enemy cover, through the clearance of jungle vegetation in the Pacific, and the military was seeking a more efficient and cheaper alternative (Neilands et al. 1972). In addition, the herbicides were envisioned as being able to destroy Japanese rice crops.

Despite such designs, the herbicides were never used in the war. Bovey (1980: 6) has speculated that ‘the rapid end of the war in 1945 and the possible accusation of conducting chemical warfare probably prompted the decision to not use phenoxy chemicals. Phenoxy chemicals would eventually be used in warfare, first by the British in Malaya from 1951 to 1953, then possibly by the U. S in Korea in 1953 and extensively in Vietnam from 1961 to 1971 (Chapter 5).

Despite initial wartime secrecy, phenoxy weedkillers became publicly known about and available in limited quantities before the end of the war, with the 1944 publication of an article entitled ‘The herbicidal action of 2,4-D and 2,4,5-T on Bindweed’ in *Science*, a pre-eminent US journal (Hanmer & Turkey 1944). DDT, another important chemical developed within wartime Big Science relationships, experienced a similar immediate entrance into civilian use. Wargo (1998) has detailed how the immense benefits of DDT, and the recognition that numerous other countries had synthesised the chemical, facilitated the early removal of secrecy provisions. While similar details are not available regarding phenoxies, it is most likely that their immense potential to aid agriculture was a significant reason for their public release (Troyer 2001: 291).

The promise phenoxy herbicides held for agriculture was their ability to be *selective* weedkillers. Previous chemical methods of weed control had relied on acutely dangerous and unreliable systemic poisons that killed the target weeds but also destroyed non-target species. However, as noted earlier, the herbicidal action of phenoxy chemicals was their ability to imitate plant hormones. By inducing hormonal reactions, the phenoxies were able to be selective, killing a specific range of weed species, while allowing other species not affected by the specific hormone to survive. Selectivity led Professor J.D. Fryer, a past president of the European Weed Research Council, to declare in 1980 that phenoxy herbicides had ‘transformed agriculture and are considered to be amongst the greatest scientific discoveries’ of the twentieth century (Troyer 2001: 290).

Phenoxy chemicals and the agrochemical revolution

Phenoxies were one of many chemical innovations, materially and symbolically supported by Big Science, that transformed agricultural practices in the post-War decades. This period was marked by the intensification of agriculture and by rapid increases in productive capacity worldwide. These increases were accomplished primarily through improved seed technology, increased mechanisation and synthetic chemical inputs such as fertilisers, herbicides, fungicides and insecticides. This period of rapid growth has been variously termed the ‘synthetic chemical revolution’, the ‘agrochemical revolution’ and the ‘pesticide explosion’ (Gottlieb 1993: 82), and in several short decades synthetic chemicals became a foundation of all advanced capitalist agricultural systems.

While the widespread adoption of agrochemical use is often universalised, its unfolding and the role of synthetic chemical and scientific discourses within it are varied, spatially specific and understudied phenomena (Lockie 1997, 2001; Wildblood-Crawford 2006). For instance, the rapid changes in New Zealand's agricultural production and the role of agrochemicals are exemplified by the country's growth in pasture production. The term 'grasslands revolution' is often used to describe the phenomenal twentieth century growth in New Zealand's agricultural productivity. Efficient pastureland management formed the backbone of the economy by allowing the production of meat, cheese, wool and butter for export to the British Commonwealth and other overseas markets (Figure 6). This agricultural economy sustained a standard of living that ranked between the third and fifth highest in the world between 1920 and 1970 (Brooking 1992). Between 1920 and 1960 New Zealand increased pasture production and yields three-fold while reducing labour inputs. While these successes were not solely the result of synthetic chemical inputs, DDT, superphosphate fertilisers, the phenoxy herbicides 2,4-D and 2,4,5-T and approximately 15,000 other chemicals in widespread use by 1960 greatly facilitated the creation of the country's 'grassland utopia' in the post-War decades (Galbreath 1998: 72).

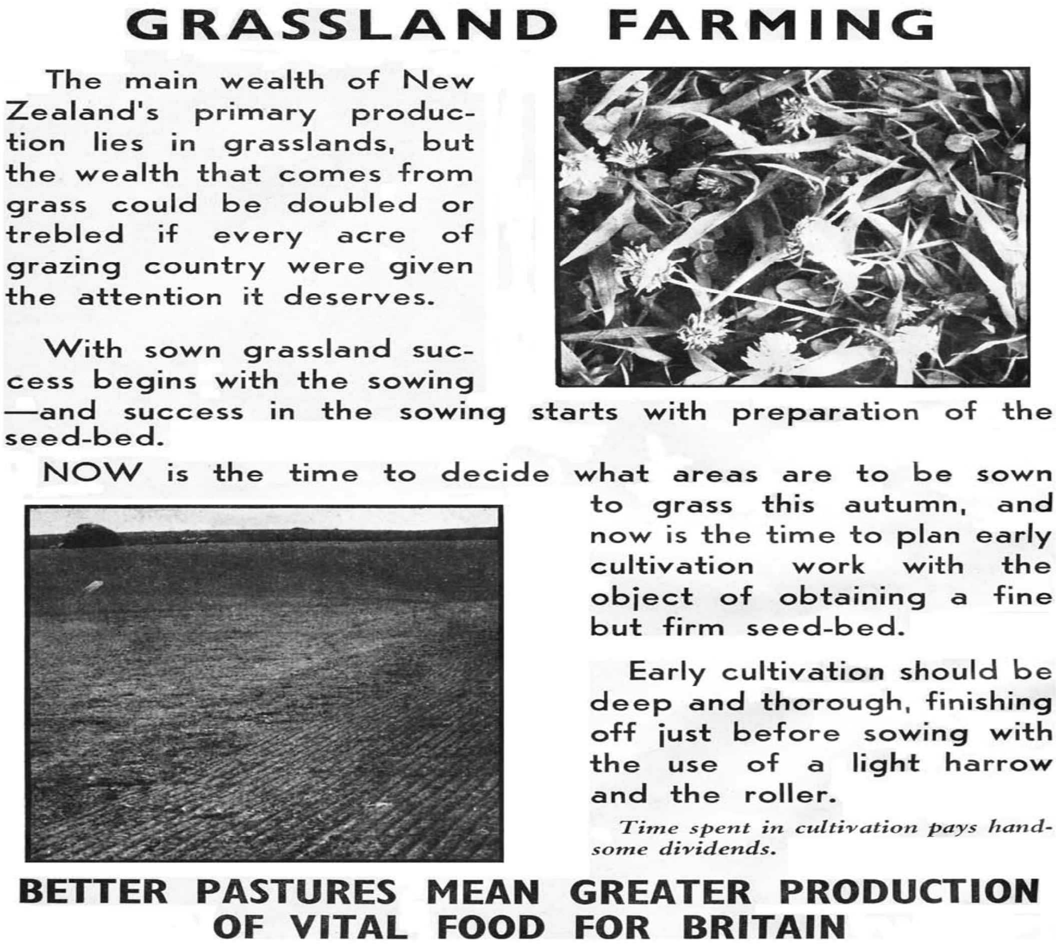


Figure 6 Late 1940s public service message demonstrating the connections between New Zealand pasture production overseas markets (*Source* New Zealand Journal of Agriculture 1948: 2)

This reliance on pasture grass production and the widespread land use changes that accompanied it have been romanticised in many New Zealand histories (Barrow 2005; Cumberland 1981; McLauchlan & Baker 2006; Smallfield 1970). Within these narratives, the role of synthetic chemicals such as 2,4,5-T in facilitating this increased productivity is represented in a heroic fashion where science and technology tamed a rampant and 'unproductive' nature. Similarly, in the case of former Director-General of Agriculture P.W. Smallfield's, *The Grasslands Revolution in New Zealand*, the use of some pesticides such as 2,4,5-T is uncritically attached as a footnote in agricultural history. Smallfield notes that 'the rapid development and use of selective weedkillers has been an outstanding feature of farm practice during the past two decades' (1970: 87). However, beyond this minimal commentary, no history of weedkillers is developed, much less a critical insight into the role of herbicides and their attendant scientific discourses in constructing the grasslands revolution.

One recent critique of this dominant narrative is Brooking, Hodge and Wood (2002), 'The Grasslands Revolution Reconsidered'. These authors do not explicitly analyse synthetic chemicals, however, they do create a space to begin charting and critiquing agrochemicals such as 2,4,5-T. In particular, they raise several important points relating to the hegemonic position that agricultural chemicals had in the post-War years of the grasslands revolution. In critiquing why the grasslands revolution occurred in such an extreme form, a simplified explanation is that agriculture represented the economic foundation of the State. New Zealand governments thus needed to maintain and improve farm sector production in order to facilitate the basic continuation of civil society (Bremer & Brooking 1993). Increasing pasture production per unit area through the use of synthetic inputs helped New Zealand prosper as a nation. And certainly in the case of 2,4,5-T, economic benefits would be central in later arguments to protect their continued use during the 1970s (Chapters 5 & 6).

The following sections build on Brooking et al, yet argue that such a deterministic and simplified focus on society–economy relationships fails to illuminate several important practices that sustained 2,4,5-T use and the grasslands revolution myth. They suggest that the grasslands revolution was very much bounded by discourses of science and research that tied national progress inextricably to an almost religious faith in the power of agricultural science to secure a prosperous future for New Zealand. Such conviction served not only to promote and sustain agriculture, but also to protect many of the key drivers, such as chemicals, from critique.

A cautious science and the nuances of phenoxy selectivity

This section argues that the initial importation and trialling of phenoxies by the New Zealand government resulted not in an uncritical endorsement of chemical use or in a bolstering of the chemical promise, as is often constructed in accounts of Big Science, but by discourses of cautious science.

Precisely when and how the first phenoxy herbicides arrived in New Zealand is unclear. Available sources indicate that government trials were underway in the country by August 1945, but they do not provide insights into who provided these first samples (Greenwood & Doak 1946). However, New Zealand's standing as a British colonial outpost with strong export links suggests that a UK government or private interest was the likely source. The potential that phenoxies offered to New Zealand agriculture, and hence to their agricultural partners abroad, is likely to have facilitated their early arrival.

As previously noted, this potential lay in the purported ability of hormone weedkillers to be *selective*. Selectivity promised to make two broad agricultural goals prevalent during the post-War years in New Zealand easier to reach: increased pasture efficiency, and 'wasteland' clearance and conversion to pasturelands. Many of the weed species hindering these goals were invasive species that fell into two broad categories. First were the woody- or brush-weeds species that colonised recently cleared areas, and included the invasive broom, gorse, and blackberry, and the native species manuka and kanuka. Additionally, it was envisioned that weeds such as thistles, ragwort and buttercups that grew in small clumps on existing pasturelands could be controlled. Being able to destroy these weeds, without harming ongoing and new pasture production, would be revolutionary.

This potential of phenoxies was asserted in advertisements in the *New Zealand Journal of Agriculture* (*NZJA*) (Figure 7). While many of the advertisements were sparse on details, the message was that phenoxy chemicals would be effective in New Zealand. However, for scientists and the Department of Agriculture (DOA), the impending phenoxy revolution appeared initially untenable. The rush to get herbicides to the public market appeared to run against the meticulous and precise endeavour of agricultural science. P.J. Hudson of the Horticulture Division, DOA, noted in 1946 (: 200) that, 'a very well known plant physiologist has stated that it was a pity that the discovery of hormones left the laboratory so soon, and that they were put to commercial use too early.' While chemists had isolated the specific chemical structure of the phenoxies during the War years, the complexities of the hormonal action of different plants meant that very little was known about how they affected certain plant families, in specific places and during different seasons.

Figure 7 Typical late 1940s advertisement for phenoxy chemicals in the NZJA (*Source* NZJA 1947: 620)

Thus, a series of government-led trials began to examine phenoxies. In August 1945, experiments at the Department of Scientific and Industrial Research's (DSIR) Plant Chemistry Laboratory in Palmerston North began (Greenwood & Doak 1946). These early trials used products based on 2,4-D and MCPA including *Dow Weed-killer* (Dow Chemicals, USA), *Weedone* (American Chemical Paint Company, USA) and *Methoxone* (Imperial Chemical Industries, UK). The trials assessed the effectiveness of the herbicides on most of the major New Zealand brush and pasture weeds, in conjunction with assessments of how much they did or did not damage widely used pasture grass species. These early trials reinforced the idea that a lack of knowledge existed. The trials were promising, but they raised many critical and unanswered questions about dose, the correct period of seasonal application, plant maturity at time of spraying and whether pasture grasses would remain unharmed.

Similar trials with tempered results began elsewhere in New Zealand. In late 1945, the DOA, Fields Division, Wellington began an extensive country-wide research programme that involved 143 experiments at 92 different sites, encompassing a range of potential uses including on establish and recently sowed pastures, drainage ditches and crops (Lynch 1947). In addition, a 'large' but unspecified number of trials occurred over the same period at the DOA's newly established Soil Fertility Research Station in Hamilton (Ward 1946). The impetus for the DOA trials was the establishment in 1946 of the Subcommittee for Chemical Weed Control as part of the larger Field Crop Committee. The Subcommittee was created when 'it was realised that developments in the control of weeds by chemicals were proceeding at a rate that demanded that a great deal of critical attention should be given to the subject' (Lynch 1948: 437). Represented on the committee and engaging in the various countrywide phenoxy trials were the Agronomy and Botany Divisions and the Plant Chemistry Laboratory of DSIR, Canterbury and Massey Agricultural Colleges, and the DOA.

As with the first trials, the results of these were less than enthusiastically received by agricultural scientists and the DOA. The selective potential of the new chemicals was tempered by caution that new synthetic chemicals could replace conventional weed-control methods. R.K. Ward, a DOA scientist, commented in 1946 (: 69) that

> careful thought should temper the enthusiasm roused by glowing accounts in popular scientific journals. Varying conditions of soil and climate make the selective killing of a weed plant surrounded by desirable species a problem of

> great complexity. The probable cost of material, equipment and labour required for application also should be a sobering consideration.

Besides dose and time of application, another crucial set of variables about which there was scarce knowledge was the environmental. New Zealand's varied soil types, topography and rainfall had long been recognised by agricultural scientists as creating distinct geographic zones for growing. This led P.B. Lynch, the Field Crop Experimentalist for the DOA, Wellington to note in 1947 (: 117) that 'all the work [with synthetic chemicals] has shown over and over again that trials must be conducted under the conditions experienced locally before definite recommendations' could be made about choice of chemical and rate of application. With these aspects initially unclear, the new herbicides, while considered beneficial, were not immediately envisioned as technologies that would revolutionise agriculture per se.

Agricultural scientists and the DOA disseminated these discourses of cautious science in articles in the *NZJA*. For instance, Lynch (1947: 117) writes:

> These results should provide a warning against applying the findings of overseas workers [sic] without test to the many different local conditions in New Zealand. Still more has the farmer to be on his guard against the sensational type of statements sometimes found in non-authoritative publications, particularly if those statements are based on overseas sources of information.

Here, the authority of New Zealand agricultural science was juxtaposed against the 'non-authoritative', presumably overseas and commercial messages that were merely 'information'. A 1946 editorial in the *NZJA* about the potential of chemical use in agriculture highlights how this approach to science is also tied to the control of nature, but only through its ability to transcend the imprecision of previous eras. While not stated explicitly, a more cautious and tempered science is needed:

> Man is believed by the unthinking to be a creature capable of moulding his environment to his will. However, his record in this respect is not very impressive when we think of the effect of the introduction of rabbits, opossums, and gorse into New Zealand, of the effects of overgrazing and burning, particularly in the water-sheds. Control by man will only be achieved if we have a genuine and thorough understanding of the forces of nature. In fact, we need very extensive ecological studies to learn to harness nature's forces so that we can live with them rather than use bulldozer methods to try to dominate them (Johns 1946: 14).

Several other factors were at work in convincing agricultural scientists that early phenoxy use should be limited. Initially, a lack of availability caused a questioning of whether the market could meet the intended demand. Ward stated in 1946 (: 67) that

> it is believed that limited quantities of various preparations are on sale overseas but that production is not yet fully under way. Only with considerable trouble has the Department of Agriculture obtained even the smallest quantities of a number of hormone preparations.

Second, when supplies were obtained, inconsistent quality control of phenoxy herbicides was rife. With poor-quality batches apparently as common as high-quality ones, the correct rates of application varied widely and the economics of using the herbicides were not always convincing.

The preponderance of the cautious science discourse is instructive for how the claims of Big Science were initially muted for phenoxies. The chemical promise of revolution and salvation for agriculture was replaced with scepticism that 'the time-honoured practices of clean farming methods can [ever] be superseded by weed control by chemical means'

(Lynch 1947: 117). This mundane and cautious approach to agrochemicals and science is juxtaposed by the next section, which examines how IWD discursively represented agrochemicals in a utopian and progressive fashion.

Ivon Watkins-Dow, the phenoxy revolution and global discourses of progress

In focusing on how the New Zealand agricultural agencies studied phenoxies, the role of the chemical industry has so far been minimised. However, by the early 1950s, private chemical companies were to assume a dominant role in field testing and trialling literally thousands of new chemicals, both internationally and in New Zealand. While government-led research on agrochemicals still existed, it was quickly dwarfed in funding, scale and authority by the research outputs of chemical corporations. This section explores the early history of IWD, the small New Plymouth chemical company, and how they employed utopian discourses about science that helped to legitimate agrochemical use. These discourses drew on international ideas about how chemicals would facilitate, amongst other things, the solving of world problems such as population expansion, insect plagues and hunger.

By the mid 1950s, several overseas companies including Shell (US) and Imperial Chemicals Industries (UK) were distributing in New Zealand small quantities of phenoxy chemicals that had been manufactured overseas. While definitive statistics are unavailable, it is estimated here that such imports accounted for approximately 10% of 2,4,5-T used in the country. Conversely, the position of IWD in the 2,4,5-T market was dominant. The company was the first to commercially import and trial 2,4,5-T, and became the only manufacturer of 2,4,5-T in New Zealand, accounting for approximately

90% of the herbicide's sales. In addition, IWD was a prominent manufacturer and supplier of the other phenoxy herbicides, 2,4-D and MCPA. The company's 40-year period of production and sales is central to understanding the country's dioxin history, because one company became the sole manufacturer and the dominant distributor of phenoxy chemicals in New Zealand. Further, IWD, as a partly owned subsidiary of Dow Chemicals USA after 1964, became a leader in voicing and defending many of the discursive ideas about chemicals, science and health that would define the dioxin controversy of the 1970s and beyond (Chapter 5).

Three British-born brothers, Ivon, Harry and Dan Watkins began their seed and nursery business in New Plymouth in 1942, after Dan returned from service in the Second World War. The company's early business focused on flowers, seeds and nursery sales through their retail shop on Currie Street in downtown New Plymouth, the main town for the large farming region of Taranaki. This area had become well known for nursery companies since the 1890 founding of Duncan and Davies. During the 1940s Duncan and Davies was the largest nursery business in the Southern Hemisphere and eventually was 'internationally recognised...[and] the largest exporter and importer of plants and shrubs in the history of both New Zealand and Australia' (Goldsmith & Barrell 1997: 31).

In March 1944 the Watkins brothers incorporated their enterprise and formed Ivon Watkins Ltd (IWD 1984: 10). With the benefit of hindsight, this incorporation purportedly occurred 'on the discovery of 2,4-D' (Ivon Watkins [IW] 1959c: 3), beginning the company's long history with phenoxies. In 1944, Dan Watkins obtained a copy of an American magazine, *Seed World*, which described the discovery of 2,4-D. *Seed World* contained an article describing the new hormone chemicals and specifically highlighted their production by the American Chemical Paint Company (ACP) of Philadelphia, the first company to commercially produce phenoxy herbicides for the public market. According to company lore, Dan Watkins obtained this magazine, and a contact in the ACP, through a fortuitous meeting with a US Air Force officer onboard a commercial flight between New Zealand and the United States in 1944 (IWD 1967). IWD initiated negotiations with ACP, and in April 1946 a formal contract was signed, with IWD becoming the sole New Zealand agent for the company's products (IWD 1968). Thus IW, previously a small nursery business, became an early and key part of the rapidly expanding global agrochemical marketplace.

In late 1946, a five-gallon can of Weedone imported by IW from ACP, arrived in New Zealand. Purportedly, all five gallons of the 2,4-D-based herbicide were divided into four-ounce medicine bottles and sent to the Agronomy Division of the DSIR and the DOA for testing (IW 1961: 27). Soon after, the September 1946 issue of the *NZJA* contained an IWD advertisement declaring that Weedone was 'at last available [commercially] in New Zealand' (Figure 8). These first commercial importations have been depicted in IWD publications as highly significant for the development of the company. For instance, in 1960 a company official noted that 'The arrival and use of this can of Weedone chemicals in 1946 marked not only a turning point in the history of the company but opened an entirely new, modern phase of agricultural chemistry in New Zealand, a potent ally for our primary industry' (IW 1960: 5).

Figure 8 One of the earliest advertisements in New Zealand for phenoxy weedkillers by Ivon Watkins for the U.S. Weedone brand (*Source* NZJA 1946: 198)

Global discourses of the chemical promise

If the 1946 can of Weedone represented the roots of a new phase of agricultural chemistry in New Zealand, it also highlighted the global connections that provided much of the material and symbolic capital that underpinned the grasslands and agrochemical revolutions. The relationship between IWD and the ACP was only one of a series of such relationships with the international chemical industry. In essence the company was dependent on global corporations for raw materials, for product branding and for some of the discursive ideas used to promote and legitimate chemicals.

For IWD a practical reason behind this dependency was the lack of basic chemical manufacture in New Zealand. Until 1969, IWD primarily *formulated* chemicals but did not manufacture them. Formulation does not create new chemical substances (as does manufacture) but instead mixes several chemicals together, resulting in a marketable product. Thus, the majority of agricultural chemicals used in New Zealand were composed of materials sourced overseas. In 1959 the main raw material suppliers of chemical products into the country were: the United Kingdom, Australia, Canada, the United States, France, West Germany, Denmark, the Netherlands, Italy, the Dutch East Indies, Japan and Peru (IW 1959d: 4).

With established sources of raw materials, IWD began to expand, in 1949 gaining the ACP franchise for Australia (IW 1959d: 8). By the end of the 1950s several of the largest international chemical companies, including Union Carbide (USA), Geigy (Switzerland), ACP (USA), Monsanto (USA) and Cela (West Germany), had financial interests in IWD through significant ownership of shares. While these international connections allowed continuity in supply of raw materials they were also highly influential in the way IWD engaged in branding itself, particularly in constructing its image around utopian discourses of science and progress. As with any commercial venture, IWD directed a portion of expenditures towards advertising. Between 1946 and early 1956, company advertising was found predominately in local newspapers and national agricultural publications such as the *NZJA* and *Straight Furrow*, the publication of Federated Farmers, New Zealand's largest rural sector organisation. Advertising raised awareness about IWD products and in simple terms motivated increasing purchase of company products.

Yet advertising was also directed at the larger project of disseminating information about the importance and necessity of agricultural chemicals. A 1960 company history noted that ‘to carry the flag of trade and the new scientific gospel an advertising section [at IWD has] gradually evolved’ (IW 1960: 6). To better facilitate these goals, in 1956 IW launched its own flagship journal, *Service: A Review of Agricultural and Chemical Progress*. *Service* was published quarterly from 1957 to 1973 and was issued to an audience numbering ‘five figures’ (IW 1959b: 3). While the pages of *Service* contained numerous advertisements for the company’s products, according to the first issue’s lead editorial (IW 1956: 26) the journal was primarily

> intended to aid production by suggesting economical, efficient short-cuts to higher output by both preventative and corrective actions. It is addressed to the smallholder and the runholder, and all those between these limits, for all have a vested interest in stepping up production from their land.

However, the journal was laden with editorials, opinion pieces, and advertisements that, usually in explicit and bold terms, laid claim to the safety, legitimacy and necessity of agricultural chemicals. Importantly, many of these articles were reprinted from overseas industry publications, thus linking and exposing New Zealand to the main hegemonic discourses purveyed by global chemical companies (Wildblood-Crawford 2006). In constructing the chemical promise, these texts drew heavily upon prevailing capitalist post-War discourses about how science and synthetic chemicals were fundamental aspects of economic and social progress.

One of the discourses that informed this utopian construction of chemicals was the necessary and winnable war against nature, particularly insects. Often, humanity was conceptualised as being locked in a battle against insects for control of nature's food supply (Figure 9).

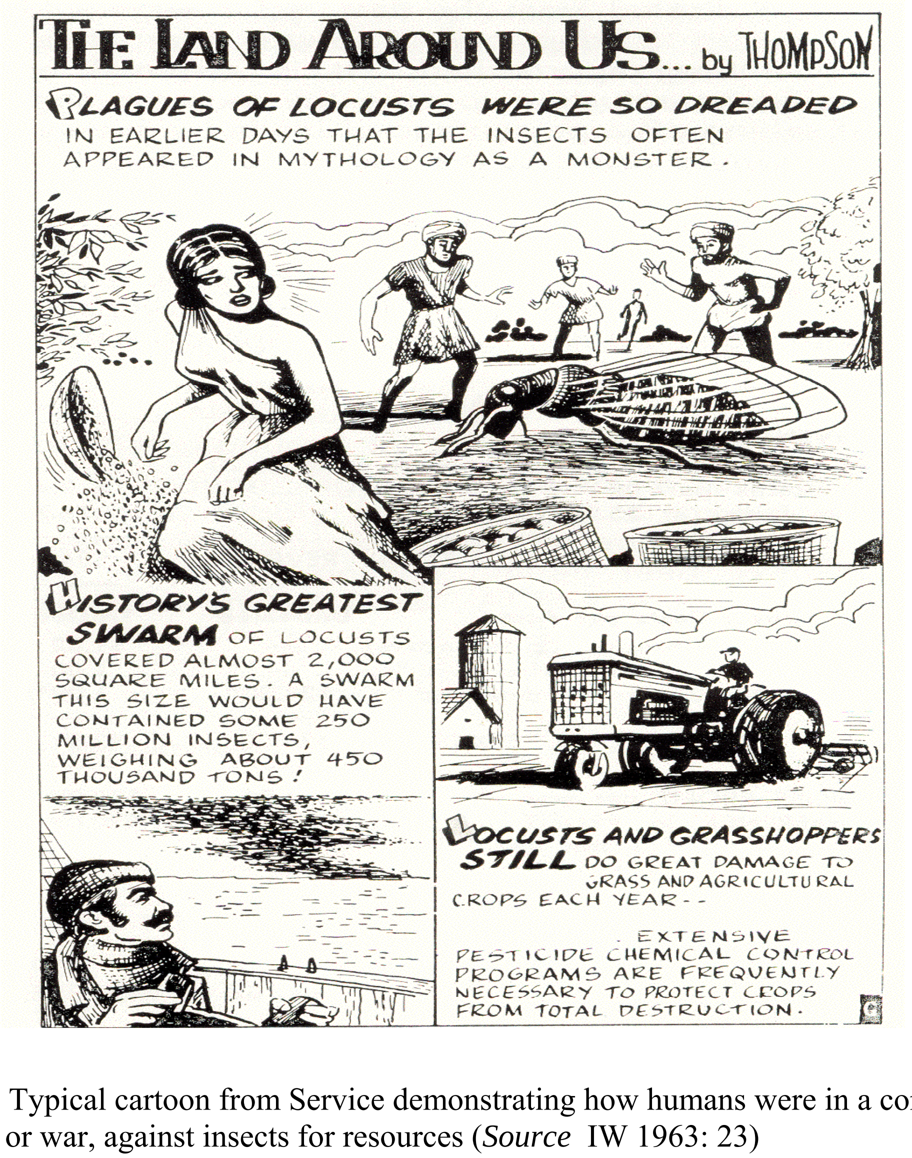


Figure 9 Typical cartoon from Service demonstrating how humans were in a constant struggle, or war, against insects for resources (*Source* IW 1963: 23)

The use of agricultural chemicals was constructed throughout *Service* as fundamentally necessary to humanity's survival. 'How Poisonous are the Modern Insecticides?' (IW 1962: 23) notes that

> Given half a chance many of these plagues would destroy vast tracts of productive country, laying waste and famine in their path. Other insect parasites, the malaria-carrying mosquito or the rat flea, can spark off disease across whole continents. Is this state of affairs to be preferred simply because the modern insecticide, essentially a safe product, might occasionally be injure man, but, mark you, far less frequently than the motor car...?

The prospects of not using synthetic chemicals were outlined in other blunt, yet simplistic terms. For instance ‘Counting the Costs if Pests are Not Controlled’ notes that ‘insects alone cost the farmer more than 1000 million pounds and nullify the work of over a million farm workers’ (IWD 1965b: 23). Throughout articles such as ‘Pests Beat People for a Large Portion of the World’s Food’ (IWD 1967–68: 18), and ‘The Alternative to Pesticides is Easily Predicted’ (IWD 1964: 30), insects were pitched in a timeless battle against humanity over resources. Also stressed was the seemingly endless potential of natural forces to overwhelm food production and to cripple progress. ‘The Desolate Year’, a reprint from the US chemical company publication *Monsanto Magazine* highlights such a doomsday scenario by describing ‘the incomprehensible turn of circumstances’ (IW 1963: 26) that would result if the United States went without pesticides for one year. As ‘the garrote of Nature rampant began to tighten...food and fur animals weren’t the only ones that died to the hum of insects that year. Man, too, sickened and he died’ (IW 1963: 27).

Russell (2004) and Wargo (1998) have demonstrated that much of this discursive construction of the war against insects had its origins in the emergence of synthetic chemicals during the Second World War. However such discourses were likely to have been influential in New Zealand in part because the war against nature was already deeply embedded in the national identity (Sinclair 1986) and was employed metaphorically in government initiatives such as soil conservation (Roche 1997).

The use of agrochemicals, especially insecticides, was linked with New Zealand's grasslands revolution and with agricultural in general by discourses that stressed the need to protect and enhance global food supplies. The lead editorial in *Service*, spring 1960, states that, 'the continued use of chemicals to control pests and disease is imperative if the world's need for more and better quality food is to be fulfilled' (IW 1960a: 2). Another article, 'Nothing to Eat in Stupidity Street' (IWD 1967: 3) and a subsection of another article, 'Chemicals or Starvation' (IWD 1965a: 12), further portrayed New Zealand's ability to increase food production via chemical use as not only imperative to national prosperity, but also as a prerequisite to being a good global citizen.

Conclusions

By the end of the 1950s, government experiments on phenoxy herbicides had been occurring for a decade and the knowledge of their use in New Zealand had grown rapidly. The quality and price of the chemicals was becoming more attractive to farmers as benefits were beginning to clearly outweigh initial start up costs (Mason 1955). Experiments had determined that good quality 2,4-D, MCPA and 2,4,5-T controlled many weeds in New Zealand under a variety of conditions. In addition, they were harmless on the pasture grass species found around the country if applied in the specified quantities.

Synthetic chemical use was normalised by both the practical efficiencies they afforded and by the symbolic discourses that were attached to them. As Gottlieb (1993: 83) has noted, 'by the late 1950s, pesticides were being touted as a kind of miracle product, supported by advertising campaigns, government policies designed to increase agricultural productivity, and a media celebration of the wonders of the new technology.' In effectively drawing on international discourses like global hunger, population explosions and insect epidemics, IWD wrapped their products and the agrochemical revolution in legitimacy. Social and material progress became increasingly difficult to separate from science. As Drori (2003) notes:

> Progress in all its forms, particularly progress as economic growth, was increasingly linked to the ability of science to transcend all barriers. Science was thus revered not solely for its instrumental value, but was linked with discourses of progress in creating a general cultural model for what societies should be like.

During the 1940s, 50s and 60s, a chemical promise was made to society that typified these relationships between science and society. As the following chapters explore, the abilities of scientific thinking to fully comprehend the implications of the chemical promise on society would be challenged.

Chapter 5: The emergence of risk and its management: 'acceptable' doses and the politicised international landscapes of early dioxin knowledge

The utopian belief that scientific wonders such as phenoxy chemicals would herald unending progress hid a darker side, one that science has struggled to rationalise and control. Dioxins have been present in every batch of 2,4,5-T since the herbicide was first synthesised in the early 1940s. However, dioxins did not become a public or regulatory issue until late 1969, when their existence was first revealed by the chemical industry.

This chapter is divided into three sections, which explore this early state of dioxin knowledge from the 1950s to the early 1970s. The first section examines the 'discovery' of dioxins and argues that the chemical industry's construction of dioxin knowledge as a private commodity forestalled government and public access to such knowledge. The second section argues that the production of Agent Orange and other phenoxy-based military defoliants is an influential, but often-misunderstood part of the history of dioxins. The use of herbicides as chemical weapons during the Vietnam War resulted in fundamental changes in the quantities of dioxin produced globally, and generated silences that have limited what we know about this early history. The final section examines the first regulatory attempts to control dioxins in the United States and how the acceptable dose discourse, a central construction about dioxins, was articulated primarily by Dow Chemicals USA (Dow), the key corporate actor in the ensuing dioxin controversy. Together, these sections detail how the chemical promise of the 1940s and

1950s began to be challenged in the face of growing uncertainty about whether science could effectively govern the use and consequences of synthetic chemicals.

The early dioxin days

The term dioxin refers to a group of 75 structurally similar molecules, the most toxic being tetrachloro-di-benzo-p-dioxin, or TCDD (see Abbreviations & Terms). In 2,4,5-T production, dioxins were unwanted but inevitable contaminants, created during the heating of tetrachlorophenol (TCP), an ingredient in the four-step process that created the herbicide. The level of dioxins created depended on the production conditions: if higher than normal temperatures and, to a lesser degree, higher than normal pressures existed during the TCP step, more dioxins were created. Whatever level of dioxin was present during the creation of TCP would be passed into the 2,4,5-T.

However, these understandings were in their infancy during the 1940s and 1950s. The knowledge that dioxins existed came about because of a skin disease that occurred occasionally in chemical plant workers. This severe form of acne had been recorded sporadically in industry workers since 1899. In the 1930s a new group of compounds, the chlorophenols, of which TCP and 2,4,5-T were part, was introduced. The increased production of chlorophenols resulted in a series of international outbreaks of what became known as 'chloroacne' (Baughman 1979: 146). As a result of these experiences, from the 1930s onwards, the chemical industry recognised that one or several contaminants, termed chloroacnegens, were present in TCP.

Further understandings about dioxins were slow to emerge. According to available histories of chloroacne (Baughman 1979), during the 1930 to 1950s outbreaks of this condition in production workers were the only obvious contaminant-related incidents occurring. These episodes happened spasmodically, with some plants going years between outbreaks and others having no recorded chloroacne incidents. While outbreaks did occur, they were not widespread considering the large size of the industry. Perhaps more significant for the chlorophenol industry was that the end users of the commercial products that relied on TCP, such as 2,4,5-T, were not experiencing chloroacne.

By 1957 the chemical structure of TCDD was formally identified (Schulz & Kimming 1957). That year, Dr. Karl Schulz, a dermatologist at the University of Hamburg, was investigating workers at a German 2,4,5-T factory operated by the Boehringher chemical company, where a large outbreak of chloroacne had occurred. He and his colleagues determined that commercial-grade TCP, 'dirty' with numerous contaminants, caused chloroacne, while highly purified, or 'clean', TCP did not. The most toxic contaminant present in the non-purified TCP was eventually isolated and identified as the previously unknown dioxin, TCDD.

Following Dr. Schulz's work in 1957, George Sorge, a Boehringer chemist, suspected that by lowering the temperature used during TCP production, the amount of dioxin created would be reduced. Sorge was correct, and following this hunch, the temperature of the Boehringer process was modified, lowering the dioxin content enough that the incidence of chloroacne disappeared from the German company's TCP production plants. According to Allen (2004), Boehringer sold the new lower-dioxin method onto Dow, the major producer of TCP and 2,4,5-T in the US. In 1958, another German chemical firm, BASF, developed a different method of reducing the creation of dioxin when synthesising TCP.

By the early 1960s, the major manufacturers of TCP and 2,4,5-T knew about the existence of dioxins and how they were produced and had begun to develop sophisticated methods of testing for them. However, the chemical industry appears to have initially treated dioxins as an industrial hygiene issue that did not affect the safety of herbicide users or the general public. While efforts were made to understand the cause of chloroacne, the sporadic outbreaks of the skin disease amongst workers did not seem to cause widespread concern or a systematised industry approach to deal with their occurrence. Allen (2004: 19) has noted that

> What is remarkable is that this information never became common in the literature. Although some toxicologists took careful notice of Schulz's 1957 paper, the problem was that no consequences were drawn and no effective distribution of the message was organised. Somehow they were unable, or did not feel called upon, to make proper use of their knowledge in terms of an effective warning [to the whole industry].

It is argued here that several characteristics of the chemical industry and the role of science within it during these early dioxin years are worthy of reflection in light of Allen's argument. The first is that the chemical industry 'did not feel called upon to make proper use of their knowledge'. One reason for this approach was the propensity for synthetic chemical processes to create contaminants. The occurrence of contaminants, also termed 'impurities', was widespread in the manufacture of agrochemicals. It was the inevitable downside of synthesising complex chemical molecules (Thornton 2000: 271). However, as long as they did not interfere with production processes or alter the effectiveness of the final product, companies would often leave contaminants in products because removing them incurred extra costs. Similarly, the chemical industry probably did not make proper use of their dioxin knowledge by sharing it with public scientists and government because they feared regulation. Chemical contaminants, at that time not regulated or examined in any great detail despite their widespread nature, had the potential to become a costly area of manufacturing modifications and legislative requirements. As V.K. Rowe (Dow USA 1965: 1), a Dow toxicologist, stated in a memo to a colleague at Dow Canada:

> This material [dioxin] is exceptionally toxic; it has a tremendous potential for producing chloracne and systemic injury....One of the things which we want to avoid is the occurrence of any acne in customers....If this should occur, the whole 2,4,5-T industry will be hard hit and I would expect restrictive legislation, either barring the material or putting very rigid controls upon it.

Second, in trying to understand how the industry was 'unable...to make proper use of dioxin knowledge', the commercial character of science and technology is evident. The extent that all manufacturers of TCP were able to access the low-dioxin trade processes of Boehringer and BASF, and whether they chose to implement them, are unclear. However, the ability to produce fewer dioxins through the improved Boeringher and BASF processes clearly became constructed as commercially valuable knowledge that had to be paid for, and less as a health issue that the whole industry should be privy to information about. Thus, the evolving knowledge about dioxins including how they were produced, how they might be managed and their toxicological profile, became a private commodity.

In summary, the production and dissemination of knowledge about dioxins initially took on a decidedly institutionalised and private form. The scientific and technological authority of certain parts of the chemical industry allowed them to control the early power/knowledge relationships of dioxins. In effect, the potentially harmful character of dioxins was hidden from public view as the visible material benefits of the 2,4,5-T outweighed the emerging concern about contaminants. However, as the next section discusses, by the mid-1960s, the entire TCP and 2,4,5-T industry would be turned on its head by the military use of phenoxy-based herbicides as chemical weapons in Vietnam. Dioxins, and the power/knowledge relationships that had developed around them in the late 1950s and early 1960s, would be considerably complicated by the widespread production and dissemination of dioxin-laden herbicides for military purposes. Dow in particular would become a central figure, both in the production of dioxins, but also constructing the discourses that would be influential in publicly defending the chemical.

Agent Orange and the beginning of the 'Dioxin Years'

The utopian discourses of progress and scientific mastery that accompanied the increased use of phenoxy chemicals during the 1950s and early 1960s (Chapter 4) reached perhaps their most sinister crescendo during the Vietnam War. While the intense momentum of Big Science had facilitated the discovery of phenoxy chemicals, the fragility of this science's ability to manage the dioxin contaminants in phenoxies would be catapulted to centre stage by unprecedented changes in their production, and their politics, brought about by military use.

As noted in Chapter 4, part of the original research focus that led to the discovery of phenoxies was for their intended, but never fulfilled, use against Japanese crops and cover during the Second World War. The US military continued to research such possible uses, including the development of large-scale spraying systems during the

Korean War. Whether the military used defoliating chemicals during this conflict is disputed, with Bovey & Young (1980: 372) stating they were not used, while more recently Coleman (2005: 91) states that herbicidal agents were used briefly during 1953, the final year of the war. The British military, however, used aerially sprayed 2,4,5-T and 2,4-D mixes in limited quantities against crops and jungle cover during the Malaya conflict of 1950 to 1953 (Troyer 2001).

In 1961, the US military began trialling eight different herbicide combinations in southern Vietnam for use in the widening conflict. The trials were successful and by 1964 the military use of herbicides had become widespread and was centred primarily on the use of Agents Orange, White and Blue to destroy enemy crops, deter enemy ambush along roads and rivers by creating defoliated buffers, and to expose hidden caches of ammunition, food and soldiers (Bovey 1980: 7). Of the eight herbicides used in Vietnam, five were either composed of 100% 2,4,5-T, or were a mixture of different esters of 2,4,5-T and 2,4-D. Agent Orange, a 50:50 mix of the phenoxies 2,4,5-T & 2,4-D, became the primary military defoliant and accounted for approximately 70% of all chemicals used. While some chemicals were sprayed by hand and by helicopter around base camps, the majority were disseminated by fixed-wing aircraft flying as part of Operation Ranchand. When US forces stopped defoliant use in 1971 they had sprayed 77 million litres of herbicides over 2.6 million hectares, or 10% of the Vietnam land area, primarily in southern and central parts of South Vietnam country (Stone 2007).

An important element of this military use of defoliants that has been left out of many narratives about the controversy is how the increased use of phenoxy-based defoliants caused a substantial supply–demand imbalance in global markets for TCP and 2,4,5-T, which led to more dioxins being created. The effects of this complex relationship are still contested in New Zealand because of a lack of industry data for the period but they can be seen clearly in the US market. As in New Zealand, one major use of 2,4,5-T in the US was for the control of woody weed species on pastures, forestry blocks and rangelands. It was also used for managing weeds in other settings: on rights of way (powerlines, highways, pipelines and railroads); in lakes and ponds; and in a range of agricultural industries, including the production of rice, cereal grains, blueberries and apples (Bovey 1980: 9). Available records indicate that the domestic use of 2,4,5-T in the US was approximately 4 million litres in 1963, compared with the 18 million litres used in Vietnam four years later. According to Bovey (1980: 5), this substantially increased demand caused civilian use of 2,4,5-T in the US to drop 50% from 1964 to 1966, while in 1967 and most likely in 1968, the US military bought *all* US-manufactured 2,4,5-T (New Scientist 1976: 385), crippling the domestic market.

The crucial, but under-studied outcome of this high demand by the US military was an increase in the production of dioxin, which was likely to have been global in scale. As discussed earlier in this chapter, dioxins were created during the manufacture of TCP, an ingredient in 2,4,5-T. Whatever dioxin was present in the TCP was passed into the 2,4,5-T. While the 1958 Boehringer and BASF process modifications had lowered the dioxin content of TCP, these processes were time- and resource-intensive. For instance, Margerison et al. (1981) notes that while the Boehringer process decreased dioxin creation approximately five-fold, it increased the production time of a TCP batch from four to 20 hours. Therefore, as TCP demand faced a steep increase, faster and cheaper, yet ‘dirtier’, production methods became the norm throughout parts of the TCP industry, and dioxins were regularly produced at high levels. In addition, the demand for TCP and 2,4,5-T resulted in a large number of new producers manufacturing the chemicals, and many probably did not have access to the trade secrets sold by

Boehringer and BASF, or they chose to ignore these technologies. In 1964 during the early period of military defoliant use by the US, 25 producers of 2,4,5-T existed. This rose to 38 by 1965 and to 52 by 1968, at the peak of Agent Orange production. As Margerison et al. (1981: 58) note, numerous 'small opportunist chemical companies joined the Agent Orange bonanza and some of them produced 2,4,5-T with heavy concentrations of dioxin', because of the rush to meet high demands.

How high the levels of dioxin were during the years of military use is difficult to estimate. One reason for this, is that as with many aspects of this period, there is a lack of publicly available chemical industry data. Another problem is that determining what the levels of dioxin were *before* the TCP market was strained is difficult, because the analytical capabilities to accurately determine dioxin levels were in their infancy (Chapter 6). Estimates given by Dow in 1971 of an unnamed US manufacturer indicate that prior to 1965, its TCDD levels were approximately 10 parts per million (ppm) in 2,4,5-T (Executive Office of the President 1971: 17). Then, during the years of military defoliant use, these most likely approached 30 to 40 ppm, with some batches recorded in the 100 ppm range (Stellman et al. 2003). After 1970, most countries moved toward a permissible level of 1 ppm in dioxin in 2,4,5-T (see below).

New Zealand during the Agent Orange years

While the basic effects of military demand for herbicides on the US TCP and 2,4,5-T market are apparent, how such use affected other phenoxy markets is less clear. In New Zealand, the supply and demand for 2,4,5-T does not appear to have been affected. According to Ivon Watkins-Dow Ltd (IWD) figures, 2,4,5-T production throughout the years of military use was steady with slight increase between 1966 and 1968 (Figure 3). Similarly, the only publicly available statistics of herbicide use for the 1960s, those in the New Zealand Yearbook, show a similar steady increase in herbicides distributed through aerial spraying, a relatively accurate indicator of overall 2,4,5-T use (Figure 10).

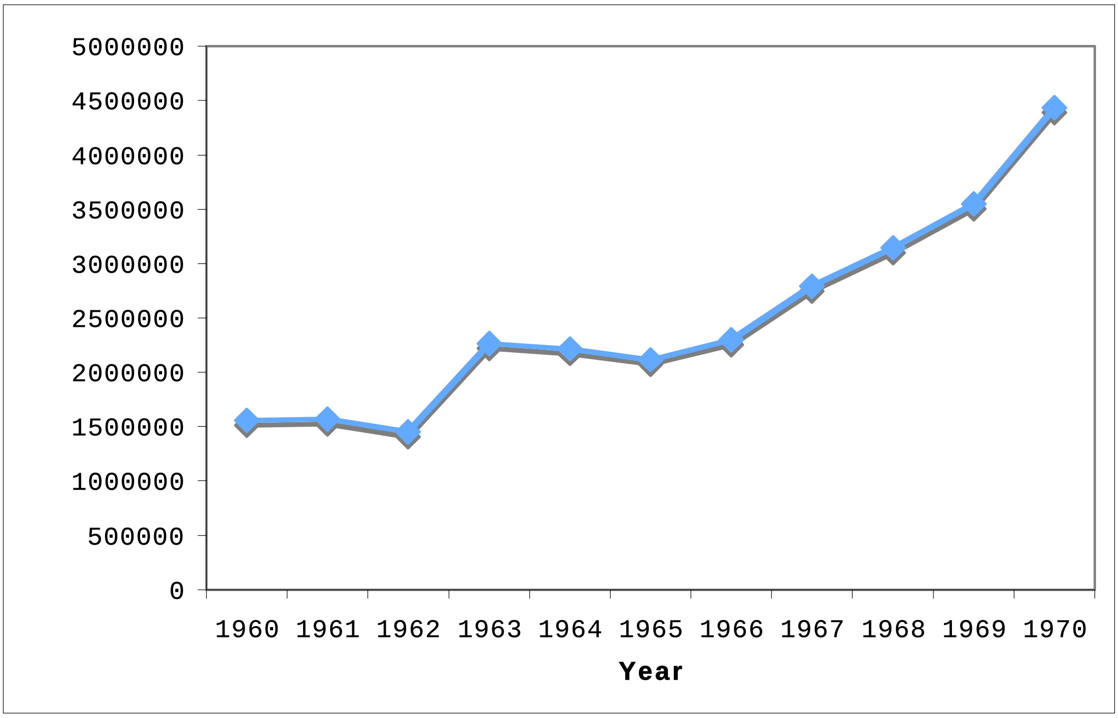


Figure 10 Litres of herbicide and insecticide distributed aerially annually in New Zealand (*Source* New Zealand Yearbook 1964, 1970,1972)

Most likely, the increased dioxin levels that have been noted in US-produced TCP and 2,4,5-T during the 1964 to 1970 period were experienced in other countries, particularly those, such as New Zealand, that continued to demand large quantities of TCP for 2,4,5-T production. With global demand for TCP strained, all producers probably would have used 'dirty' production methods more than previously. Until late 1969, when a TCP production facility came online in New Plymouth, IWD imported TCP, and thus dioxin, into the country from several overseas companies. While IWD has never publicly disclosed where their TCP was acquired, one New Zealand government report states that the chemical came from a source in Germany (Boshier & Boland 1992: 8). The true extent of dioxin contamination in TCP that was used in New Zealand is unknown; however, it was probably high compared with other periods.

However, several statements by government officials have hinted that high levels of dioxin contamination were prevalent during this period. Following a January 28, 1972 meeting at IWD, Philip Allingham, the Assistant Director, Occupational Health & Toxicology, Division of Public Health, Department of Health (DOH), handwrote on a memo (DOH 1972a) that George Mason, the Director of Research at IWD had told him that 'Before 1969 IWD imported the basic materials [TCP] for making 2,4,5-T and this probably contained highish levels of dioxin.' Similarly, during testimony to the 1986 Ministerial Committee of Inquiry to Advise on the Impact on Health of the Residents in New Plymouth from the Manufacture of Pesticides, Ron Pilgrim, the long-serving New Plymouth Regional Air Pollution Control Officer, stated: 'In my opinion the manufacture of 2,4,5-T from 1964 to 1969 inclusive from imported TCP is the most likely principal source of TCDD found in soils analysed' (DOH 1986: 62). No explanation or clarification of this statement has ever been given. These statements strongly suggest that the TCP IWD imported during the Vietnam War years was highly contaminated. This lack of understanding regarding 1960s dioxin levels in 2,4,5-T represents a significant silence, one that poses a barrier to resolving contemporary dioxin grievances (Chapter 8).

Besides importation of highly contaminated TCP, the possibility that military defoliants were made in New Zealand also exists. In July 1967, during the beginning of peak Agent Orange use, IWD and the New Zealand and US governments clearly entered into discussions of whether IWD could produce and export herbicides for military use. On July 12, 1967, Hutchings, the New Zealand Secretary of Defence (1967a: 1), wrote the Rt. Hon. J.R. Marshall, Minister of Defence, noting that the US Army 'had a requirement…for 1M [million] gallons of defoliants for use in South Vietnam.' The letter outlined how IWD had become interested, and that Dan Watkins, the CEO of IWD, had had discussions with the Commercial Attaché at the US Embassy. Further, the Minister wanted 'the maximum effort by the Ministry of Defence to be made to get this project going and to assist in getting the material to South Vietnam (NZ Secretary of Defense 1967a). Only two other letters that detail these discussions are publicly available. One, dated July 14, 1967, is between the New Zealand Chief of Air Staff (1967: 1), Air Vice Marshall C.A. Turner and Hutchings where 'the feasibility of the RNZAF [Royal New Zealand Air Force] accepting a commitment to air-transport defoliation chemicals to the US forces in Vietnam on a regular basis at an initial rate of 10 tons per month' was discussed. Second is a July 20, 1967 letter, again between Hutchings and Marshall, where they discuss a meeting that Hutchings had with G.A. Hays, the Commercial Secretary at the US Embassy (NZ Secretary of Defense 1967b).

While these letters were not made public until the late 1980s, the existence of such discussions was briefly reported in the media at the time. On July 25, 1967, the *New Zealand Herald* ran a front-page story entitled 'New Zealand May Make War Chemicals' (: 1), which stated:

> A New Zealand manufacturing firm negotiating with the United States government for a contract to make defoliants for use in the Vietnam War...Mr. D. A. Watkins, managing director of Ivon Watkins Dow Ltd of New Plymouth said yesterday that nothing was certain as yet but that his firm would certainly like to begin producing defoliants...He did not feel that there was a moral issue involved and asserted that he had a completely clear conscience.

This public disclosure appears to have caught IWD and the US and New Zealand governments off guard and each began to distance themselves from the issue. On July 29, 1967, the *Herald* reported in an article entitled ‘No Defoliants Negotiation Says Embassy’ (: 1) that

> The United States Defence Department in Washington had entered into no negotiations with any New Zealand source to provide defoliants a US embassy spokesman in Wellington said last night. The American embassy had questioned Washington after reports that a New Plymouth company was negotiating with the US government for a contract to make defoliants. Mr. D. A. Watkins, managing director of Ivon Watkins Dow Ltd said last night he could not comment on the Wellington report. When told the substance of the Embassy statement he said , ‘If they say that, I guess it’s right.’ When it was suggested that the statement appeared to contradict what he was earlier reported to have said, Mr. Watkins repeated that his firm had decided to ‘stop making comments’.

The issue lingered for several weeks, but was seemingly laid to rest when on August 8, 1967 Prime Minister Keith Holyoake contradicted the early-July correspondences between the Minister of Defence and the New Zealand military and stated in Parliament (NZ Parliamentary Debate 1967: 2150) that

> The Government had in no way involved in the matter, and the above advice received from the US Government through the American Embassy in Wellington…was that the American Government was in no way interested in purchasing defoliants from New Zealand for use in Vietnam.

In 1990, in response to complaints from New Zealand Vietnam Veterans, a committee was launched to investigate the claims that Agent Orange had been made in New Zealand. The *Report of the Foreign Affairs and Defence Committee on the Inquiry into the Manufacture of Agent Orange by Ivon Watkins-Dow in New Zealand During the Period of the Vietnam War* concluded that ‘evidence provided to the Foreign Affairs and Defence Committees as to whether Agent Orange was manufactured in New Zealand during the Vietnam War was inconclusive' (Foreign Affairs & Defence Committee 1990: 3).

This section has argued that the military use of 2,4,5-T resulted in unprecedented high levels of dioxins being produced when compared with normal production of the herbicide. While New Zealand may or may not have actively participated in making military defoliants, high levels of dioxins were likely to have been imported into the country in TCP contaminated as a result of the wartime production strains on global markets. Today, the long-term consequences of these high dioxin levels on the human and environmental health of Vietnam, on the US, Korean, Australian and New Zealand soldiers who were exposed, and on the places where 2,4,5-T was manufactured, such as New Plymouth, have become centre stage in claims of injustice linking the past to the present (Chapter 8).

Beck's notion of manufactured uncertainty (Chapter 2) is useful here because it highlights the fragility of science's ability to know about and control dioxins. The creation of more dioxins because of the intensification of 2,4,5-T production for military purposes allowed dioxins to escape from the weak boundaries that science had established for their control. The chemicals were no longer able to be spatially limited, and as evidenced today, they have defied temporal limits as well. Beck has argued that this weakening of the spatial and temporal boundaries of pollutants causes the 'language of prediction and control [to] lose its pertinence' (Beck 1992: 12). The utopian discourses of science that were evident in the 1950s and 1960s would face substantial challenges during the 1970s, in part encouraged by the manufactured uncertainty that pollutants like dioxin would exhibit. As the remaining chapters argue, the chemical industry and governments would cling to reductionist discourses of science in establishing risk assessment as a governance strategy. However, the influence of these discourses would only ever be partial in convincing a more skeptical public that dioxins were able to be rationally controlled.

Another point to consider about military herbicide use and the early understandings of dioxins discussed previously are the numerous gaps in knowledge about the period that still exist. In part, these silences are because mundane industrial processes such as TCP manufacture are not always the subject of publicly accessible history, due to a perceived lack of interest and/or because commercial sensitivities have restricted such information. However, as discussed in Chapter 3, some of these silences appear deliberate because of the contentious issues that surround this period.

The public emergence of dioxin knowledge and the acceptable dose discourse

In order to begin deconstructing the history of the early dioxin discourses in New Zealand, it is useful to examine the initial public emergence of the issue in the US. The unfolding of these events was crucial to how the issue would be handled internationally for the next 35 years. The term ‘risk assessment’ was not used widely until the late 1970s. However, the initial debates around dioxins in the earlier part of the decade helped define several important discourses about risk assessment as an approach to governing chemical-human relationships. As discussed in the first section of this chapter, during the 1960s the existence of dioxins was unknown outside of the chemical industry. It is argued here that this lack of government and public knowledge about dioxins, and a regulatory structure in the US in the midst of sweeping changes, created a vacuum that was effectively filled with chemistry industry discourses, particularly those of Dow. While governments internationally undertook legislative steps to regulate dioxins, such governance was done primarily within the bounds of understanding about the chemical that was being publicly articulated in the US, and by reductionist approaches to science then dominant in policy-making.

On October 29, 1969 Lee DuBridge, the Scientific Advisor to President Nixon, announced that the use of 2,4,5-T in the US should be heavily restricted because of potential effects on human health. Among the multi-agency limitations proposed were that all uses of 2,4,5-T on food crops would be banned after January 1, 1970 unless the US Food and Drug Administration (FDA) could establish safe tolerances. Further, the Departments of Agriculture and the Interior should cease using 2,4,5-T in their own programmes in populated areas or where residues might affect humans. The 1969 DuBridge restrictions were based on the results of what became known as the 'Bionetics studies', begun in 1964 by the US National Cancer Institute. These studies focused on screening the most common pesticides then in use for their carcinogenic (causing cancer), mutagenic (causing gene alteration) and teratogenic (causing birth defects) potential.

The Bionetics analysis of 2,4,5-T was completed in August 1968 and was given in early 1969 to the National Institute of Health, representatives of the chemical industry and the National Academy of Sciences. The report findings were not made public, purportedly because of the need for more statistical analysis (Wildavsky 1995: 88). However, a staffer working for consumer advocate Ralph Nader on the food regulation practices of the FDA found a copy of the report in the FDA files in September, 1969 and mentioned it to a friend at Harvard University. Via this connection, Matthew Meselson, a Harvard biology professor and an early critic of the use of Agent Orange in Vietnam, obtained a copy of the Bionetics report (Whiteside 1970). Meselson notified DuBridge of the Bionetics findings, and within weeks the announcement was made that 2,4,5-T use would be restricted because of previously unknown contaminants, dioxins.

Despite their forceful tone, the initial DuBridge announcements actually resulted in no real restrictions on 2,4,5-T use in the US. The Departments of Agriculture and the Interior argued that they would wait for more test results before they implemented any restrictions. Similarly, the testing by the Food and Drug Administration, meant to be completed by January 1970, was delayed. Whiteside (1970) has noted that this slow response to the DuBridge restrictions revealed how tangled the legislative pathways in the US then were for assessing and regulating synthetic chemicals. The creation of the Environmental Protection Agency (EPA) in December 1970 would streamline some of these legislative pathways, but in effect, few clear precedents or methodologies existed for how authorities should examine the complex teratological results of the Bionetics report and how they should decide on the next steps. Further, there was a paucity of government knowledge about what dioxins were, how they were produced and what their effects were on biological health, which slowed action.

The public construction of dioxins was occurring in a tumultuous and contested landscape where the governance of chemicals was being challenged both by social movements and regulatory reforms. As Brickman et al have noted (1985: 19):

> By the end of the 1960s, worldwide concern about the harmful effects of industrialisation and technological change coalesced into insistent public demands for remedial State action. The governments of the advanced industrial nations responded with ambitious programs of "social regulation" to protect public health and the environment. Wide-ranging statues were

> enacted granting broad new regulatory powers to executive agencies. Environmental and labor groups mobilised to extend the regulatory agenda and press for faithful implementation of the law. Confronted with costly and onerous legal obligations, industries sought to contain the scope of State intervention by intensifying their efforts to influence public authorities. In little more than a decade, these activities changed the face of regulatory policy and politics in every industrialised country.

Dioxins were some of several groups of synthetic chemicals that, by the early 1970s, had been thrust into the spotlight. DDT, the thalidomide tragedy of birth defects and the contamination of food supplies by synthetic chemicals had become significant public issues. Traces of synthetic chemicals were being found virtually everywhere scientists looked. The increasing analytical capabilities of science to detect chemical residues in food, human tissues and the environment were in part driving popular and government pressure to further understand and regulate pesticides. Commenting on this period, Gottlieb (1993: 96) notes that 'the darker side of a technologically centered society began to become clear', and thus the role of industrial 'progress' in creating hazards and pollution were becoming the foci of popular and government calls for reform. The belief that science could foresee and control the effects of technologies, were being challenged by calls for a more precautionary approach to regulation.

A significant event that would highlight these debates between chemical progress and the calls for reform, and that would establish a key dioxin discourse internationally, were the April 1970 (US Senate) *Effects of 2,4,5-T on Man and the Environment Hearings before the Subcommittee on Energy, Natural Resources, and the Environment of the Committee on Commerce* of the US Senate, otherwise known as the Hart Hearings (Senator Phillip Hart was Chair). The testimony presented by chemical industry executives, academics and government officials over two weeks demonstrated the extensive debate that existed about how chemical governance should occur.

These hearings can also be viewed as the first public positioning of Dow as the primary and most vocal defender of dioxins for the next 35 years. This relentless leadership has been both material and symbolic. Materially, Dow was the largest of eight military defoliant manufacturers for the US government, and as a world leader in analytical chemistry it became the pioneer in the early 1970s of dioxin monitoring techniques (Crummett 2002; Chapter 6). Symbolically, the Dow name became synonymous with dioxins and the connections between war and chemicals. Before dioxins and Agent Orange became the focus of public scrutiny, Dow had experienced some of the most intense anti-war activism in the US for their production of the jellied-gasoline bomb material, napalm, which was widely used and implicated in civilian deaths during the Vietnam conflict. As Ned Brandt (1997: 362), a former Director of Public Relations for Dow noted about this period, ‘In 1970 much of the world seemed to be unhappy with Dow.’ However, Dow and its associated companies around the world, such as IWD in New Zealand, actively promoted, legitimated, attacked and defended most of the major ideas about dioxins, and as such can be considered the major corporate actor in the dioxin controversy.

Within several weeks of the DuBridge announcements, Dow had suggested in press releases that the 1968 Bionetics results were flawed because the 2,4,5-T used on mice in those tests contained abnormally high levels of dioxins. At the April, 15 Hart hearings, Dow officials extended this argument (US Senate 1970). Julius E. Johnson, Vice President and Director of Research at Dow, described how the 2,4,5-T used by government scientists in the Bionetics tests was acquired in 1965 from the Diamond-Shamrock Company. He argued that this 2,4,5-T was contaminated with between 15 and 30 ppm dioxin and that Diamond-Shamrock no longer produced 2,4,5-T. While not directly alluded to, these higher than normal dioxin levels are likely to have been connected to the previously described effects of TCP production as a result of military demand for herbicides. In further testimony, Johnson acknowledged that during the 1960s other manufacturers had also produced 2,4,5-T with elevated levels of dioxins (in the range 10 to 30 ppm), but he stated that such levels were not representative of the 2,4,5-T industry at the time, and certainly not as of 1970.

Johnson also detailed how Dow had been aware of the ‘highly toxic impurity’ (US Senate 1970: 361) since the 1950s and that the company was able to crudely monitor the levels of the dioxin contaminant through the use of a rabbit ear test that indicated the presence of contaminants. By early 1965, the development of gas chromatographic analysis was allowing Dow to test 2,4,5-T for dioxins down to 1 ppm, and according to Johnson, this level had been maintained in their products. Through this testimony, Dow strongly argued that 1 ppm dioxin in 2,4,5-T was, barring the occasional exception, the norm.

Further, Dow contended that the 1 ppm dioxin, unlike the elevated levels of the Bionetics samples, would not cause birth defects. Dr. Johnson stated that following the DuBridge announcements, Dow officials met with representatives from the National Cancer Institute and the Food and Drug Administration (FDA) on November 25, 1969, to press them to allow Dow to conduct a further teratological study using 2,4,5-T of ‘regular production grade’, containing 1 ppm dioxin (US Senate 1970 :374). The government agencies concurred, and by January 12, 1970, Dow reported the findings of their quickly arranged study to the FDA. According to Johnson, ‘This report showed that the Dow 2,4,5-T of regular production grade [1 ppm] did not cause birth defects as determined by gross examination of the fetuses’ (US Senate 1970: 375).

Dow's promotion at the Hart hearings of 1 ppm as the normal and safe level of dioxin had several outcomes. First was that the unsavoury production practices that had typified the industry during the past, particularly during military use of 2,4,5-T, were constructed as not the industry norm, but as the actions of only a few companies. This has helped to silence the past, and has precluded a looking back to better understand the industry practices of the 1950s and 60s. Second, the debates around the health effects of dioxins were brought firmly within the discourses associated with the toxicological frameworks that chemical regulation had been operating under since the 1940s. In 1970, the primary method used to test for health effects of pesticides and the primary data required for registration of these chemicals in the US, New Zealand and most other countries was *acute toxicity*. Manufacturers had to show at what level their products would cause serious acute harm or death, and then work out a reasonable safety margin (Thornton 2000: 72). Acute toxicity is based on the core tenet of toxicology commonly referred to as 'the dose makes the poison'. It is founded on the idea that all substances are toxic at high enough doses, and conversely, all substances are safe at low enough doses. It is argued here that ppm was a discourse that normalised acute toxicity as the basis of governing dioxins and refocused the debate onto what would be an safe and *allowable* dose of dioxin.

Yet the 1960s Bionetics tests, the Hart Hearings and the increasingly vocal opposition to chemicals had in some ways signaled the potential for a new approach to chemical regulation, one that challenged the adequacy of the existing acute toxicity basis of pesticide legislation. In a 1971 editorial in the journal *Science* (Wade 1971: 312), Wellford reflected that this period of the 2,4,5-T/dioxin controversy symbolised

> a battleground of opposing philosophies about the relationship between technological risk and human safety. Arrayed on one side...are typically the classical toxicologists, food technologists and agri-chemical engineers, who are trained to look for the short term effects of pesticides, both in their impact on the human body and on the pests in the field. On the other side are typically the microbiologists and geneticists, the specialists in the causes of cancer, birth defects and mutations, who are professionally concerned with the long-term effects of chemical contaminants on human health. At stake is the question of who is to set the standards upon which the proposed safety of a pesticide (or any chemical) is to be judged.

By examining the carcinogenic, teratogenic and mutagenic potential of pesticides the Bionetics tests were moving away from the simplistic acute toxicity discourse that had dominated pesticide regulation. Instead, the complex interactions between chemicals, human bodies and changing environments were beginning to be considered. Evidence that chronic effects such as cancer did not become apparent for several decades, that some substances had differing effects on the foetus, children and the elderly, and that certain chemicals actually had greater effect at low doses, were all posing challenges to the discourse of acute toxicity.

These uncharted spaces presented challenges to chemical governance that up to that point had relied upon, and arguably revered, simplistic assumptions about rationality, objectivity and certainty, instead of the complexity, ambiguity and uncertainty inherent in real-world human-chemical interactions. Commenting at the Hart Hearings on the difficulties of managing chemicals in these uncharted spaces, DuBridge (1970: 21) noted that

> The Bionetics study represented a step up in degree of sophistication of research. Certainly this evolutionary process is a highly commendable situation…There do exist some dilemmas, however. The major dilemma accrues from the fact that there is no real end point to this questioning process. The more research that is performed, the more new questions will be raised about the chemical under investigation. That is, it is quite obvious that

> decisions will virtually always have to be made on admittedly incomplete information. Perhaps the goal we should seek is a sufficiently flexible system to allow us to change our minds when confronted with new information, coupled with an explicit acknowledgement of the perpetually interim state of our scientific knowledge.

DuBridge's statement is an early, albeit slightly weak, articulation of what has become known as 'the precautionary principle'. This counter discourse recognises the inherent inability of science to adequately understand, among many things, the complexities that arise as the result of human exposures to synthetic chemicals. However, as the following chapters demonstrate, this 'perpetually interim state of scientific knowledge' highlighted by DuBridge would not become a recognisable part of governing dioxins. Instead, the discourse of acceptable dose, epitomised by the 1 ppm dioxin level in 2,4,5-T, and other discursive elements of risk assessment, would rely on constructing human-chemical interactions as knowable through the tools and procedures of science.

Conclusions

This chapter has argued that the significant increase in dioxin levels caused internationally by the production of military herbicides during the Vietnam War is a key facet of the dioxin controversy. The weak boundaries that science had established for dioxins were overwhelmed by unprecedented changes in the wartime production of TCP. This production can be thought of in governmentality terms as a 'problematisation', or a specific situation where the activity of governing is called into question (Dean 1999a: 27). However, knowledge about dioxins and the extent of the 1960s dioxin contamination was obscured from public view by chemical companies who constructed dioxin knowledge as a private commodity.

The 1 ppm acceptable dose discourse promoted by Dow was the initial governance response to this problematisation and is an example of both the enabling and excluding character of discourses (Mills 1997). The notion that a safe and acceptable level of dioxin existed enabled dioxin governance to develop within the knowable and rational frameworks of acute toxicity and toxicology. In the seemingly unknown spaces of dioxin knowledge, this discourse also enabled the perception of a degree of control by industry. This position substantially precluded debate about the potential for a precautionary approach to chemical governance and instead allowed the production of dioxins to continue. The silenced and commodified dioxin knowledge that had existed since the 1940s became obscured as the discourse of 1 ppm excluded an examination of this past.

Finally, this chapter has highlighted how understanding the power/knowledge relationships and governance of chemicals requires a recognition that numerous scales are involved. The intense production of TCP for military purposes altered similar manufacturing processes internationally. The prominent role of Dow and the significant legislative actions concerning dioxins undertaken by the US government established the key 1 ppm acceptable dose discourse that would be followed by most governments internationally, including New Zealand's. How New Zealand was positioned in these global flows and how it interpreted and contributed to them is argued in the following chapters.

The chemical promise discussed in Chapter 4 began to unravel in the 1960s and 1970s, partly because of the inability of science to 'control' the movement of chemicals out of factories and into bodies, communities and the environment. However, with increased opposition being promoted by various social movements who called for a more precautionary approach to chemical governance, the chemical industry and governments effectively constructed arguments, such as acceptable dose level of 1 ppm, to re-exert the authority of science in the face of uncertainty. The following two chapters examine the techniques, mechanisms and vocabularies that were utilised in negotiating such uncertainty and how these approaches were influential in the formation of risk assessment as a governance strategy.

Chapter 6: Early landscapes of risk management in New Zealand: science as management and the management of science

The acceptable dose discourse outlined in Chapter 5 was premised on the toxicological principle that all substances have both a poisonous and a safe dose. By arguing that 1 part per million (ppm) dioxin in 2,4,5-T was the safe dose, Dow Chemicals USA (Dow) grounded chemical governance in seemingly rational knowledge. This chapter examines how the acceptable dose discourse was put into practice in New Zealand from 1969 until the mid-1970s.

The first section briefly discusses the two key risk assessment sciences, toxicology and epidemiology, and argues that these approaches to understanding human exposure to chemicals are hindered by chronic uncertainties. The second section describes how the New Zealand government interpreted the US restrictions on the use of 2,4,5-T around homes, water and food. It argues that the uncertainties inherent in understanding dioxins were obscured and minimised in favour of using science to manage and rationalise continued 2,4,5-T use. The last section argues that while the ability to detect minute traces of chemicals has often been cited as contributing to the growth of anti-chemical movements, the case of dioxins in New Zealand can be viewed in a different light: the legislated focus on monitoring excluded other approaches to dioxin governance and helped solidify the acceptable dose discourse. Together, these sections demonstrate that while the dominant scientific approaches to understanding human–dioxin interactions struggled in practice with uncertainty, this was obscured from public view in favour of managing the continued use of 2,4,5-T.

Epidemiology, toxicology and the limits of knowledge in risk assessment

Epidemiology and toxicology have been central to the governance of chemicals, both in the decades preceding the development of risk assessment in the 1970s and since. They have and continue to be the dominant forms of scientific inquiry that provide the information that is used in making decisions about chemical exposure and human and environment health. Contrasted with genetic determinants, environmental determinants of health represent a range of factors, including tobacco smoke, interpersonal violence, poor water quality, motor vehicle accidents and synthetic chemicals such as dioxins (Clapp & Ozonoff 2004: 201). Epidemiology and toxicology attempt to quantify how exposures external to the body can lead to physical changes in humans or other organisms. Through the use of controlled experimental procedures, normally in a laboratory setting, toxicology exposes test subjects to specified substances to assess how certain doses elicit certain effects (Timbrell 1995). Epidemiology seeks to predict and to study the occurrence of disease in existing populations and attempts to determine the causative factors that explain the observed patterns (Wing 2000: 30).

Like many scientific fields, epidemiology and toxicology adhere to an analytical approach that is characterized by Cartesian reductionism, where factors are considered in isolation from their contexts. Research within sociology (Kroll-Smith et al. 2000; Brown 1997; Wing 2000) and science and technology studies (Jasanoff 1990, 2004; Kleinman 2005) have criticized this reductive approach as inadequate because it ignores the uncertainty and complexity that characterise human exposures to synthetic chemicals. Kroll-Smith et al. (2000: 10) outline four such uncertainties that highlight the limitations of toxicology and epidemiology as used in risk assessment. In reality, these factors are interdependent of each other and separated here only for analytical clarity.

The first uncertainty is the basic toxicological tenet of dose–response relationships, alluded to in Chapter 5 with the 1 ppm discourse. Certain doses will elicit specific responses, and typically they follow a linear relationship, where higher doses cause more effect. Toxicology is fairly accurate in determining the body's immediate response to acute and high doses of single substances. However, the ability to measure low doses over long periods, the typical exposure for much of the human population, is very limited (Wing 2000).

Second, epidemiologists have difficulty quantifying the body's past exposure to the wide range of potential environmental agents. Routine medical care for the general population does not record such information, and thus epidemiologists operate with a deficit of information regarding potential exposures. Third and directly related to past exposures, is the issue of synergistic effects, or how multiple factors might interact. While research and understanding into synergy are increasing, the reductionist basis of toxicology still encourages a focus on how single substances act in isolation.

The last uncertainty described here is what Vyner (1988: 61) has termed 'aetiological uncertainty', or the lack of the ability to conclude that a certain disease is caused by a specific factor. Confounding variables are abundant in environment–human relationships and epidemiologists struggle to effectively isolate a causative factor(s) for many diseases. These uncertainties have led Kroll-Smith (2000: 10) to conclude that understanding the complexities of human exposures to synthetic chemicals is hindered by the 'endemic presence of uncertain knowledge'.

These uncertainties provide a broad context for helping to critique how the acceptable dose discourse was put into practice and how such practices reveal the situated, malleable, politicised and often non-objective character of toxicology and epidemiology. The next section begins such a critique by examining the New Zealand government's first reactions to dioxin governance as it was emerging in the US.

The management of science and science as management in New Zealand

The New Zealand government officially learned of the US DuBridge restrictions in a November 4, 1969 letter from the US Embassy in Wellington to the Director-General of Health (Embassy of the US, Wellington 1969). This letter was forwarded to several government agencies, including the Agricultural Chemicals Board (ACB). The ACB was a quango established by the 1959 Pesticides Act and was the body responsible for registering agricultural chemicals, for approving their labelling and for promoting them (ACB 1966). The Board's membership includes representatives from the farmers' and growers' organisations, from the agrochemical industry, and from the Departments of Agriculture, Health and Scientific and Industrial Research (Brewerton 1974: 79).

Initially the ACB adopted a wait-and-see position. At the November 7, 1969 meeting of the ACB Insecticide and Fungicides on Horticultural Crops Committee meeting, a resolution was passed: 'That the Board ask the proprietors [of 2,4,5-T] to keep in touch with all information received from the USA and that they keep the Board informed of any such information' (ACB 1969a: 1). At a full Board meeting two weeks later, the desire to wait for the US data was reaffirmed and the following agreement was recorded: 'no further action need be taken by the Board at this stage' (ACB 1969b).

While the DuBridge announcements had called for certain restrictions on 2,4,5-T use in the US, because of legislative uncertainty and questions about the data, these were not immediately implemented (Chapter 5). However, in April and May 1970, legislative actions that did result in real restrictions on 2,4,5-T use were announced in several countries, including the US, Canada and Australia. Although not identical, the restrictions cited the teratogenic potential of dioxin and focused on stopping 2,4,5-T application around homes and waterways, and on food crops (Table 2).

Table 2 1970 Restrictions on 2,4,5-T use in the US, Australia and Canada

Country	**Date**	**Restrictions**
United States	April 15, 1970	• Suspension of registration of liquid formulations [of 2,4,5-T] used around the home and on lakes, ponds, and ditch banks • Cancellation of registration of non-liquid formulations of 2,4,5-T around the home and on all food crops intended for human consumption • Use can continue on range, pasture, forests, and rights of way and other non-agricultural land
Australia	April 21, 1970	• The use of 2,4,5-T in areas where water contamination could occur should not be permitted • All persons exposed to 2,4,5-T in its manufacture and use should use special precautions, such as protective clothing, to ensure that skin absorption did not occur • Until further evidence is available, special precautions should be taken to avoid exposure of women, particularly those of child–bearing age group to 2,4,5-T
Canada	May 11, 1970	• The registered status of 2,4,5-T formulations for use on lawns and in recreational areas is cancelled as of May 14, 1970 • Registrants are requested to stop sale immediately on their 2,4,5-T formulations represented for use on cereals • Precautionary labeling for 2,4,5-T formulations…are to warn that applications are not to be made to water, along ditch or stream banks, or to wet lands feeding into potable water sources; or to recreational areas, such picnic grounds, golf courses or parks

Source: verbatim from (Australian Public Health Advisory Committee 1970; Canada Department of Agriculture 1970; United States Senate 1970)

However, besides a requirement in August 1971 for a label warning about use around water, New Zealand would not implement any similar restrictions until April 1972 (Chapter 7).

On the surface, the two-year delay in restricting 2,4,5-T use was indicative of the prominent position the chemical had within the New Zealand economy. The use of 2,4,5-T had been increasing steadily throughout the late 1960s. Between 1968-1970, use of 2,4,5-T expanded rapidly, doubling over two years (Figure 10). This more routine and expanded use was partly the result of $3.3 million of annual government subsidies on agricultural chemicals introduced in June 1969. The cost of chemical control of weeds had grown disproportionately to farm incomes and some suggestions were being made that weed control had been suffering around the country as a result (NZ Parliamentary Debates [NZPD] 1969: 1221). The subsidies reduced the factory price of 2,4,5-T by 37 to 50% and held costs constant with price controls (Public Expenditure Committee 1972: 21). The ACB was fully aware during the 1970 to ‘72 period when restrictions were debated, that the continued use of 2,4,5-T was essential to the expansion and maintenance of pasturelands across the country. The Superintendent of the Department of Agriculture (DOA) noted during the 1972 ACB Subcommittee on 2,4,5-T meeting (ACB 1972b: 5) that the

> continued use [of 2,4,5-T] would be required in forestry, and in farming…the only alternative to 2,4,5-T (picloram) was more persistent and one of its drawbacks was that legumes i.e. clovers failed to re-establish for some time in areas where picloram had been used. In certain areas e.g. forestry use of 2,4,5-T was indispensable.

In assessing the non-precautionary approach to managing dioxins that New Zealand took during the 1970 to ‘72 period, the importance of economic imperatives should not be minimised. However, in seeking to understand how the dominant discourses of dioxin governance became normalised, other factors, particularly power/knowledge relationships, need to be considered. Thus, the following section examines how the 1970 2,4,5-T restrictions on use around water and human habitation and on food implemented by other countries were discussed, rationalised and discursively constructed by the government and the chemical industry in New Zealand.

2,4,5-T and food crops

The initial focus of concern for the ACB was the impact of potential 2,4,5-T restrictions on food crops that had been suggested in the US. The only registered use for 2,4,5-T on human food crops in New Zealand was for apricots. IWD's 2,4,5-T based Fruitone A was used on Newcastle, Roxburgh Red, Dundonald, Trevatt and Moorpark varieties of apricots, primarily to hasten maturity and improved the colour and size of fruit. However, such use was very limited: 20 to 30 gallons a year were used during the 1968 to 1970 growing seasons (DOA 1970).

Of more concern, and ultimately more vexing for the New Zealand government, was the use of 2,4,5-T on blackberry. Along with gorse, blackberry was the primary invasive weed for which the herbicide was used. While not a food crop per se, the fruit was routinely harvested by the general population on public and private land. Further, the standard spraying regime for blackberry was to spray during fruiting, and therefore the ACB began to explore whether this constituted a danger to human health.

In a letter to IWD (ACB 1970a: 1), the ACB Registrar stated:

> It is noted that many labels for 2,4,5-T refer to treating blackberries at the fruiting stage and the question is raised as to whether there should be any warning that berries that have been sprayed should not be eaten. In practice, the wilting of sprayed bushes would deter pickers unless they came along very shortly after ripe berries had been sprayed. No doubt you realise we do not think that any 2,4,5-T residues on fruit would be harmful. In practice,

> picked fruit would probably have no detectable residues, or at the most such residues would be almost negligible. As a result of my recent overseas trip I feel strongly that collectively, we in New Zealand, and the Board in particular, must endeavour to prevent public opinion becoming strongly anti-pesticide as is the case in the USA. Therefore the Board must take, and appear to take, any necessary action to ensure that agricultural chemicals are used safely. The Board must be able to say that it investigates cases of hazards and alleged hazards.

Following this tack, the ACB asked the Department of Scientific and Industrial Research (DSIR) to test blackberries. The DSIR undertook an experiment where they dipped blackberries in 2,4,5-T, let them drain and then weighed them to see how much was retained. The ACB (1970b: 2) stated that:

> Based on the [DSIR] work our conclusions are that if a person ate 8 ozs (227 mg) of blackberries per day he could ingest up to 0.5 mg/kg 2,4,5-T per day. This does not give a tenfold safety factor as the lowest dose at which laboratory animals showed effects [from dioxin] was 4.6 mg/kg.

These calculations were based on the US Bionetics birth defects data that had used 2,4,5-T containing 27 parts per million (ppm) dioxin. The ACB asked the DSIR to recalculate their figures based on the 1 ppm level that had become uncritically accepted internationally as representative of the entire 2,4,5-T industry (Chapter 5). When the ACB recalculated using 1 ppm, the safety factor of ingesting blackberries was 60-fold of when toxic effects from dioxin would be expected. This was still very low compared with typical safety factors of 100 or 1000 then used. Despite these findings, the ACB proceeded with a regulatory approach that discounted the objectively derived safety warnings in place of a strategy that allowed continued use. They noted (ACB 1970b) that

> sprayed blackberries look inedible within two or three days of spraying and the smell of sprayed blackberries is offensive after spraying. It is considered that blackberries would not be eaten any time after the first or second day spraying.

In the September 2, 1970, the Department of Health (DOH) concurred that it would not be practical to deny the use of 2,4,5-T for the control of blackberry. The DOH agreed that a general warning to the public should be made 'that wild blackberries being a weed are sprayed from time to time with toxic chemical substances' (DOH 1970a).

In October 1970, the ACB asked the Municipal Association of New Zealand, the trade group that sprayed public areas for weed control, to warn the public about blackberry spraying. The letter (ACB 1970c: 2) stated:

> The Board…considers that it would be most desirable if members of your organisation could, when spraying blackberries particularly in built up areas, advise the public by way of newspaper and radio…and warn that these [blackberries] should not be eaten. The Board also considers that it would be desirable that where possible a prominent notice be placed on the site where the blackberries were sprayed. I would add at this stage that it is not the Board's intention to completely restrict the use of 2,4,5-T in New Zealand as it is of considerable importance for waste and scrub weed control and there is no satisfactory alternative method of control for blackberries. I am sure members of your organisation would only be too willing to assist the Board especially in view of the widespread public opposition that could result if such decisions were not taken.

Whether blackberries presented a potential route of human exposure to dioxins, and what the ingested dose of the chemical may be, had been superficially determined. However such understandings were far from being established with any degree of certainty. The ACB and DOH engaged in a vague process of assessing these risks, while the benefits of 2,4,5-T use clearly weighed in on the decision-making process. In this case, science was malleable and *managing* the risks presented by dioxins was driven more by a need to insure continued use of the herbicide, than by notions of objectivity.

2,4,5-T and the contamination of water

The US, Canadian and Australian restrictions of 1970 stressed avoiding the contamination of water with 2,4,5-T. However, the possibility of such contamination translating into human health concerns received minimal attention from the New Zealand government. In July 1970 the ACB outlined its thinking on the international restrictions in a letter to the DOH. Despite discussing the ACB position on food crops and home use of 2,4,5-T, no outline of water concerns or clarification from DOH on public implications of water contamination was sought (ACB 1970b). The September 3, 1970 DOH reply noted this absence and upon review of 'the available literature and evidence' stated that 'In public water supplies a nil present [of 2,4,5-T] should be aimed at. The use of 2,4,5-T on the catchments of public water supplies would need close surveillance' (DOH 1970b: 1). However, during the remainder of 1970 and the first half of 1971, the ACB instead focused almost solely on the potential of food contamination.

In mid-1971, the first strong public voices questioning the possible health effects of dioxins centred their discussions on water-borne contamination. On June 11, 1971, Robert Elliot, a professor of Paediatrics at Auckland University, was interviewed on the weekly radio programme, 'Country Session'. Professor Elliot stated that a sufficient dioxin dose capable of causing birth deformities could result from the aerial spraying of 2,4,5-T, which he argued often resulted in large quantities drifting off target. Elliot's assertion had some resonance. According to ACB figures for 1971, 21% of the 254,000 gallons of 2,4,5-T used were applied aerially (ACB 1972c). In addition, many New Zealanders in rural areas used rooftop rainwater collection as their primary water source. Complaints of spray drift were commonplace in rural areas as helicopter spraying increased substantially in the late 1960s-early 1970s.

Following the 'Country Session' programme and one of similar content the following week, questions were raised in Parliament on June 23, 1971 about 2,4,5-T and water-borne contamination. Mr. Tizard, Pakuranga, asked the Minister of Agriculture whether 'any tests on the effect of herbicide 2,4,5-T when sprayed…on water supplies for human consumption had been carried out…' (NZPD 1971: 1374). In a decidedly cryptic answer, the Minister responded that 'Water supplies for human use suspected of having received the material [2,4,5-T] have been chemically tested with negative results' (NZPD 1971: 1374).

Another vocal critic of 2,4,5-T who would emerge in 1971 and stress water contamination was Robert Mann, Lecturer in Biochemistry, University of Auckland. At the August 14, 1971 Rotorua Conservation Society Seminar on Pollution, Mann presented '2,4,5-T: An unregulated danger.' In this wide-ranging paper, he offered calculations that showed that drift from aerial spraying could deposit quantities of dioxin sufficient to endanger developing foetuses in pregnant women who consumed normal quantities of water. In response to these accusations, the ACB Chairman offered this rebuttal of Mann's position (ACB 1971d: 1):

> It is noted that you state that aerial spraying causes a clear danger to humans and should be severely restricted. This point was carefully discussed by the Board. The possibility of spray getting on to a roof of a farm house and thence into a domestic water supply is remote, but if it did happen the farmer and his wife would know of it, particularly as susceptible plants surrounding

> the farmland would show symptoms of hormone weedkiller damage…Even if a direct application of 2,4,5-T, containing 1 ppm of dioxin…were made to a 1500 sq ft roof into an empty rain tank, and assuming the average intake of water per day for a 60 kg person is about 3 litres then the human being could ingest 0.015 micrograms/kg/day of dioxin. If there was this direct application to the farm roof the non-target species would be so badly twisted that the farmer could not be unaware of what was going on and would take precautions to disconnect the water supply. The amount of contamination from drift would be very much lower than the maximum rate I have quoted above.

Several ideas are relevant here. First is that when faced with public criticism that employed science-based arguments, the ACB's reaction was to deploy similar rational arguments. Despite the Ministers assertion that tests had been performed, no evidence of such tests is available in archived ACB correspondence or meeting minutes. The uncertainty about what constituted a harmful dose of dioxin and how these could be determined in rural water supplies was not acknowledged, but instead was replaced with toxicological quantifications that appeared irrefutable.

Second, the ACB approached the issue of water restrictions from a primarily reactive position. At the August 25, 1971 ACB Executive Committee meeting it was decided that considering the ongoing publicity, a label warning should be adopted. Resolution EX 71/15 was passed, requiring that the labels of all 2,4,5-T products include the wording: 'Avoid contamination of any natural, public, private or domestic water supply' (ACB 1971c: 3). However, such warnings did not have to appear until a proprietor's next printing run, or two years, which ever was sooner.

Summary

This section has examined how the DuBridge announcements and the first discussions about dioxin as a contaminant in 2,4,5-T were received in New Zealand in the early 1970s. While the US, Canada and Australia took steps to reduce the use of 2,4,5-T in 1970, citing the unknown effects of dioxins, New Zealand interpreted these spaces differently. As a DOH letter noted (1970c: 1), the government's approach was a 'low key endorsement of the US official statements adapted to NZ conditions'. The water restrictions and blackberry actions taken by New Zealand authorities highlight how the governance of dioxins, via toxicology and epidemiology, were driven by the idea of *managing* how the dioxin controversy was being constructed publicly. The practical realities of understanding and accurately assessing the possible routes and timing of dioxin exposures were complex. However, the inability of science to immediately comprehend this complexity, was not publicly acknowledged. Instead, the ACB and DOH appeared to uncritically accept the shortcomings of toxicology and epidemiology. Instead, rationalising incomplete information in such a way as to allow effective management became normalised.

Permissible levels and the beginning of monitoring

In 1970, the chemical industry in the United States, led by Dow, had suggested that the dioxin content of 2,4,5-T was a constant 1 ppm. Chapter 5 described this as the acceptable dose discourse and noted that it helped legitimate chemical industry claims that dioxins were able to be rationally and objectively understood, despite widespread uncertainties about the human and environmental health impacts of the chemical. Regulatory efforts internationally and in New Zealand were initially focused on whether the use of 2,4,5-T should be restricted in certain places (in water, around homes, on food crops). However as this section describes, by mid-1971, the regulation of dioxins became centred on insuring continued 2,4,5-T use through the maintenance of a ‘safe’ dioxin level in the herbicide. Using new technologies to monitor these ‘permissible levels’ became the sole focus of dioxin regulations internationally over the next 15 years. This section argues that the initial 1 ppm acceptable dose discourse was reinforced and supported by the professed ability to accurately detect tiny amounts of dioxin. Monitoring these levels gave the chemical industry and government credibility and the illusion of control at a time of great uncertainty.

Beginning in 1970, Ivon Watkins-Dow (IWD) assured the ACB and the DOH that all their 2,4,5-T products contained 1 ppm TCDD or less. The ACB appeared to accept this, and at the July 8, 1970 Board a member stated: ‘I understand from the major New Zealand manufacturers of 2,4,5-T that their production runs of 2,4,5-T contain less than 1 ppm dioxin’ (ACB 1970b: 2).

However, it appears that the DOH felt obliged to legislate this limit in some way in order to fall in line with other countries. In March 1971, the New Zealand government passed Amendment No. 5 to the 1956 Poisons Regulations. Under the amendment, 2,4,5-T could be sold with *more* than 1 ppm. In such cases the herbicide would be classified as a *restricted poison* available only to commercial users, and a purchase license would be required. However, the ACB stated this was just a precaution and they had received assurances from IWD and importers that all 2,4,5-T would contain less than 1 ppm dioxin (ACB 1971a). Thus, users could expect the herbicide to be sold only as an *unrestricted poison*. As the following section discusses, this confusing stance was initially based on trust between the government and IWD because the ability for government to actually measure and consistently monitor such levels was still several years away.

Just two months after the New Zealand limit was formalised, US government action further reduced the permissible level of dioxins in 2,4,5-T. In May 1971, the prestigious US National Academy of Sciences (NAS) submitted its *Report of the Advisory Committee on 2,4,5-T* (Wilson 1971) to the newly formed (December 1970) Environmental Protection Agency (EPA). The report recommended several actions be taken, which relied on maintaining specific dioxin levels and establishing long-term monitoring. These included: a limit of 0.5 ppm TCDD be set for all existing inventories of 2,4,5-T, all formulations used around homes and in recreational areas be limited to 0.1 ppm and a limit of 0.1 ppm be implemented in all future production of 2,4,5-T. To accomplish this, the report stated (Wilson 1971: 64–66) that

> Manufacturing standards must…be subject to continued monitoring…Surveillance should be maintained by requiring that a manufacturer submit a reference sample and a certified analysis of each future production lot to the EPA.

New Zealand would not announce similar restrictions until April 1972, when the Agricultural Chemicals Board released its *Report of the Subcommittee on 2,4,5-T* (Chapter 7). Amongst other recommendations, the ACB fell in line with the US restrictions, requiring that all 2,4,5-T manufactured or distributed in New Zealand after April 1973 contain no more than 0.1 ppm TCDD.

This reliance on testing and monitoring for dioxins was in part the result of rapid technological changes in how synthetic chemicals could be detected in minute amounts. Wargo (1998: 156) describes the main advances and how

> Over a period of only two decades [1950–1970s], detection limits [were] reduced by nearly six orders of magnitude. By 1952…paper chromatography was used to detect a variety of chlorinated hydrocarbon insecticides, including DDT…in the part per million range…By 1962 gas chromatography was capable of identifying seventy-one separate pesticides, with some detectable in the 0.02 to 0.2 ppm range…Refinements of the mass spectrometer in the 1970s…revolutionised environmental chemistry and our understanding of how pesticides move through the environment…Detection beneath the part-per-billion level became possible.

These technological advances also acted to invigorate public discourse about chemicals and health. The unseen and hidden nature of synthetic chemicals was replaced by the ability to 'see' synthetics in food, human tissue and the environment. In the 1950s, the detection of chlorinated hydrocarbon residues in food became the focus of government actions to regulate chemicals, and Carson's 1962 *Silent Spring* described how analytical chemistry research had revealed contamination in a range of animals and environments. Wargo (1998: 69) argues that by the 1970s, 'health and environmental advocates… relied on advances in analytical detection technology…to devise arguments favouring precautionary regulation.' In such a light, monitoring technology was integral in revealing the extent to which synthetics had caused contamination and can be thought of as one of the roots of increased chemical regulation in the 1970s (Gottlieb 1993). While such constructions of testing and monitoring have validity, they should not be universalised. The following section argues that the evolution of dioxin monitoring in New Zealand did not necessarily create spaces of resistance to the dominant acceptable dose discourse during the early 1970s, but instead entrenched the acceptable dose discourse.

The struggle for accuracy

As with many aspects of New Zealand's chemical politics in the early 1970s, the role of IWD and the ACB and their reliance on overseas knowledge are crucial for understanding dioxin monitoring. Gas chromatography, the analytical tool that would be most important during the early 1970s dioxin testing, had become established in New Zealand in a very limited capacity only in 1969. While IWD and DSIR had the pre-eminent chemical laboratory facilities in the country, the ability to detect dioxins was an emerging technology being developed primarily by a handful of international chemical companies. Dow was a world leader in analytical chemistry and had developed one of the earliest methods of detecting dioxins. The corporate relationship with Dow, coupled with their in-house lab, positioned IWD as the New Zealand leader in dioxin monitoring.

As noted in Chapter 5, in initially promoting the 1 ppm defence of dioxin, Dow stated that it had been at the forefront of detecting contaminants in chlorophenols since the 1930s. It had created a toxicological test that became a crude but reliable standard for assessing contaminant levels. Known as the 'rabbit-ear test', the procedure consisted of wiping suspect materials onto the inner ear of laboratory rabbits and observing the reaction (Adams et al. 1941). It is unknown to what extent such testing was regularly used throughout the industry, but Dow states it employed the method to routinely monitor TCP production (US Senate 1970). Dow then became one of the pioneers of gas chromatography during the late 1950s, and in 1964 Dow scientist Harold Gill developed an analytical technique for detecting TCDD using gas chromatography. By

1965, Dow was able to detect 10 to 20 ppm TCDD in 'dirty' technical-grade TCP, and down to 1 ppm in 'cleaned up' laboratory-grade TCP (Wildavsky 1995: 83). The other major international company at the forefront of dioxin monitoring was Boehringer. In response to outbreaks of chloroacne at their plants (Chapter 5), the German firm had in the early 1960s developed the leading method of lower-dioxin TCP production, a process that Dow and IWD both used via licensing arrangements.

Because of the lack of publicly available records (Chapters 3 & 5), it is unclear what, if any, dioxin monitoring IWD itself undertook prior to 1970. However, when monitoring became the focus of dioxin governance, IWD drew heavily on its overseas relationships. In an early discussion with the ACB, the company stated (IWD 1971: 1-2) that

> C.H. Boehringer of Germany, under whose Company we are licensed to manufacture 2,4,5-T in New Zealand, have analysed our trichlorophenol and found that it consistently contains less than 1 ppm dioxin.

Further, the early 1972 'IWD Half-Year Report to Shareholders' noted (IWD 1972b: 2) that

> We have carried out extensive tests and investigations to ensure we are meeting all requirements. We have also made available to the ACB all information we have received from overseas on the results of testing. This testing is much more sophisticated than any so far carried out in NZ.

IWD used this reliance on international knowledge as a discursive strategy that sought to legitimate the accuracy of testing and the concept of monitoring. Yet such overseas connections were also motivated by the practical void of dioxin monitoring experience in New Zealand. As will be discussed next, neither IWD nor the government initially had a reliable method of monitoring for dioxins.

The ACB contacted the Chemistry Division of the DSIR in early 1971 and asked whether they would be prepared to monitor dioxins in 2,4,5-T. DSIR's response was affirmative, but cautious, noting that the method would take some time to develop. As Jim Ellis, the Director of DSIR, stated later in the year (DSIR 1971: 1):

> The analytical task envisaged is a demanding and complex one and, although we have set the stage to begin work on it as soon as the new international method arrives, I would expect that there will be a long preliminary period of testing of the method in our hands.

In a July 22, 1971 letter, the ACB informed IWD that DSIR was ready to carry out testing on the company's 2,4,5-T. A local representative from the DOA would come to New Plymouth and be present while the samples were drawn. However, the letter also indicated (ACB 1971b: 1) the weak state of DSIR monitoring and the extent to which the government was almost exclusively reliant on IWD for understanding how to test for dioxins:

> I have now been advised that the Chemistry Division DSIR are ready to carry out tests to determine the dioxin level in 2,4,5-T produced in your factory…It could also be useful in the early stages of Chemistry Division's evaluation, to be able to compare the results they obtain with those you may have obtained…Chemistry advise they are not in a position to specify the amount of acid [2,4,5-T] which is required for the tests….and I would therefore be grateful for your help in this matter. Accordingly would you please therefore despatch the quantity required for testing.

In reality, these early samples were used to begin the process of DSIR's learning to sample for dioxins, not to truly initiate a monitoring programme.

During this same period DSIR was hesitant to invest too much into its analytical procedures because indications were that authorities in the US and Europe were attempting to develop a standardised method. However, by September 1971, DSIR indicated that the international method, originally thought to be only weeks away, would in fact be delayed for up to a year and it would have to proceed without it. One possible reason for the delay was that internationally, it was proving difficult to distinguish dioxins from the numerous other contaminants present in 2,4,5-T. Gas chromatography produced a graph-like profile, with dioxin displayed as a substantial spike on the results sheet. However, other contaminants produced similar spikes and thus it was difficult to accurately determine the dioxin level. Extensive refining of the sample was therefore necessary to remove as many other contaminants as possible, making the attainment of a testable sample very laborious. Even by early 1972, contaminants were still the major stumbling block preventing a regular monitoring programme (DSIR 1972: 1):

> These are relatively crude substances by analytical standards and, in common with workers abroad, we have found that the method of analysis is scarcely equal to the task of analysing dioxin absolutely in such products.

Despite these difficulties, DSIR appears to have been a quiet leader internationally in attempting to formulate methods of monitoring dioxin content in 2,4,5-T. By early 1974 DSIR was able to monitor every batch of herbicide manufactured by IWD that year and most of the small number of imported 2,4,5-T consignments. This testing was able to be done to a level of 0.05 +/- 0.02 ppm. New Zealand appeared to be ahead of many other countries in its dioxin monitoring scheme. In a late 1973 letter, Fred Tschirley, the Pesticides Coordinator of the US Department of Agriculture (US DOA) to Dr. Watts, the Registrar of the ACB seemed unaware of New Zealand's ability to monitor dioxins (US DOA 1973: 1):

> The analysis of dioxin are difficult ones because of the low levels that are being found. To this date only Dow Chemical Company in Midland, Michigan, has demonstrated the analytical capability required. Several other labs are developing the analytical capability. The Environmental Protection Agency will soon be ready to analyse blind sample....This Department expects to get into the game in September at a laboratory in Beltsville, Maryland.

New Zealand's scientific prowess was limited compared with the major international laboratories that were examining dioxins. However, the importance of 2,4,5-T to the agriculturally oriented economy meant that the preservation of herbicides use was given priority, and monitoring became central to such a strategy, perhaps much earlier than in other countries.

Conclusions

In outlining the 1 ppm acceptable dose discourse during the 1970 US Senate hearings, Dow confidently stated that it had been monitoring its 2,4,5-T supplies since 1965 and that the levels had always been less than 1 ppm dioxin. However, it is clear from the New Zealand experience that these claims obscured the initial difficulties of measuring such levels, particularly as part of a regular monitoring strategy. Instead, dioxin monitoring was until 1974 a tentative activity that relied on largely experimental methods. While the improved analytical ability to 'see' chemicals has been cited as a contributor internationally to anti-chemical movements that were seeking more precautionary means of governance, the development of dioxin monitoring did not seem to open up such spaces in New Zealand. Instead, despite the early difficulties of being able to accurately assess dioxin levels, monitoring facilitated, not challenged, the acceptable dose discourse and allowed it to become the dominant idea behind dioxin governance.

The notion that science is limited and unable to obtain adequate and complete knowledge, and that human-chemical interactions are constituted by a range of uncertainties, was minimised. This is partly because of the 'systematised reliance' (Thornton 2000: 25), of synthetic chemical production and regulation to go forward then ask questions later. As Barry Commoner (1989: 366-7) has noted about dioxins:

> In practice, risk assessments have not been used as tools to evaluate the environmental risks of different regulatory alternatives…invariably the new technology is chosen in advance of the risk assessment; therefore the assessment of risk is not used to decide which technology to use, but rather how to best defend the choice already made. With the decision already made, the risk assessment becomes the means of defending the decision, rather than the objective basis for it.

The assumption is clearly that science and technology will resolve what they create. Several ideas follow on from this. First, this approach negates the questioning of whether certain chemicals should even be 'released' in the first place. Second, science becomes less an objective tool removed from the realities of culture and politics, and instead it becomes intertwined and malleable, able to be used selectively to achieve certain goals. Toxicology and epidemiology are especially susceptible to such differing interpretations because they are inherently burdened by uncertainty.

Chapter 7: Resisting the chemical promise: oppositional discourses and the limits of rationality

The possibility that dioxins might cause birth defects has been a central narrative internationally in the dioxin controversy. The public disclosure about the existence of dioxins in late-1969 was spurred on by the US Bionetics study that suggested 2,4,5-T contaminated with dioxins caused birth defects in mice (Chapter 5). As a result, the legislation enacted in many countries in the early 1970s focused on limiting possible dioxin contamination of food and water supplies. However, the incidence of dioxin-related birth defects in the general population of these countries did not feature strongly in initially justifying the new regulations. This chapter describes how, by 1972, the reporting of birth defects in different parts of New Zealand allegedly connected to dioxin exposure became prominent. For the remainder of the decade, public concern about birth defects and dioxins would ebb and flow in intensity, punctuated by several prominent events, which this chapter describes.

This chapter examines the period 1972 to mid-1977, in particular focusing on how several of the voices of opposition to the dominant understandings of human–dioxin interactions provided insightful critiques of how dioxins were being governed in relation to birth defects. The first section argues that anti-chemical sentiment was constructed by the chemical industry as being driven only by emotions and was therefore devoid of constructive insight on 2,4,5-T and dioxins. The second section discusses how the 1972 Agricultural Chemicals Board Subcommittee Report on 2,4,5-T investigating birth defects reinforced the acceptable dose discourse by discursively limiting alternative perspectives. The third section examines epidemiology and birth defect monitoring, in particular discussing how several groups questioned the ability of these tools to understand birth defects. Overall, the chapter argues that while oppositional discourses to the dominant acceptable dose discourse existed, they had limited success in challenging the truth claims forwarded by the chemical industry and the government.

The narrow constructions of anti-chemical sentiment

The previous chapters have noted that the 1970s were marked by a range of voices that began to contest the chemical promise. This section argues that the New Zealand voices of opposition to the dominant understandings of dioxins were part of these debates and the substance of their arguments is most clearly seen in their engagement with birth defect issues. While this activism was multi-faceted, hybrid and arguing for a more precautious approach to managing chemicals and risk, it was narrowly constructed in public and private discourses by the chemical industry, the Department of Health (DOH) and the Agricultural Chemicals Board (ACB).

The dominant discursive construction of individuals and groups who questioned whether the dioxin contamination of 2,4,5-T might cause birth defects was that they were non-objective and over-emotional. Such constructions had been featuring strongly in the wider debates about the relationships between technological risk and human safety then becoming prominent in many Western countries. The chemical industry was arguably the most blatant purveyor of these ideas, most of which had been widely promulgated since the early 1960s, forming a central argument against Rachel Carson's

Silent Spring (Graham 1970; Wildblood-Crawford 2006; Chapter 4). Chemical companies adopted aggressive public relations strategies that sought to construct all anti-chemical sentiment as emotional and irrational. For instance, in the early 1970s, Dow Chemical USA (Dow) (in Whiteside 1979 : 17) noted that

> Countervailing forces must be applied to areas which have been subject to overwhelming emotional pressures of only one kind, so that the environmental pendulum will be swung from environmental extremism to reasoned centre and we may all move forward constructively to deal with the major tasks at hand.

The idea of the existence of a 'reasoned centre' – a common metaphor used throughout the 1970s – implied that scientific rationality was stable and balanced, unlike the unpredictable character of other viewpoints. Sentiment was similar in New Zealand, where the controversy over DDT had become intense during the late 1960s and the chemical had been banned in mid-1970. P.J. Clark, the chairman of the ACB, stated in the opening address of the 24th annual Agricultural Chemical and Animal Remedies Manufacturers Federation Conference (Ivon Watkins-Dow [IWD] 1971: 19) that 'We live in a climate with a critical public whose emotional state can be very close to a condition of unstable equilibrium. It may not need a tremendously significant event to trigger it off.'

Such constructions, already widely employed, had resonance when allegations that dioxins in 2,4,5-T could cause human birth defects began to become more prominent. Undoubtedly, the experience of a child being born with a serious birth defect elicits a wide range of 'emotional' responses for individual parents, the family and the community. However, these responses were publicly constructed in a way that acted to oversimplify and dichotomise the emotional and the rational. In a *Service* article entitled

‘IWD management presents facts about the use of 2,4,5-T’ (IWD 1972c: 22), it was noted that

> No exception can be taken if the reporting of this information [ideas about birth defects] is objective. We have confidence in the public’s ability to judge what is objective reporting and what is merely publication of statements and opinion, and to judge if attempts are being made to fit facts to a pre-conceived conclusion.

Similarly, Dan Watkins in a report to the shareholders (IWD 1972b: 2) stated that

> Lately the herbicide 2,4,5-T has been under suspicion in an atmosphere of conflict between the idealist and the realist. We must all hope this does not develop into a conflict between science and emotion, because in those circumstances there can be no winner. It is a well known fact that periodically throughout man’s [sic] history emotion has all but wiped out the pursuit of knowledge.

By 1977, such constructions were seemingly entrenched. As Garth McQueen, the Director, National Poisons Information Centre, and a consultant to the DOH noted (1977: 6):

> It is unfortunate that the extremely high toxicity of TCDD has often produced an emotional response which clouds the rational consideration of the question: Is it possible for a pregnant woman to receive from the 2,4,5-T used in New Zealand an exposure of TCDD which is teratogenic or otherwise harmful to the developing embryo or foetus?

One argument that further entrenched the ‘only emotional’ construction, and that endures today, is that activism against dioxins was primarily an extension of the anti-war movement, because dioxin-contaminated defoliants had been used during the Vietnam War. For instance, Whiteside (1979: 15–16) commenting on the US situation, described how Dow maintained that much of the 1970s reaction to dioxins was because the

> objective consideration of the whole 2,4,5-T issue has been obscured by "emotionalism," and that, in effect, the company has been victimised by what purports to be scientific criticism but is essentially an argument of a "political" nature arising out of the vehement opposition of certain members of the scientific community to the Vietnam War.

Similarly, in New Zealand, George Mason, a chemist for IWD stated (1975: 126) that 'real public interest in 2,4,5-T did not develop until it was used as a defoliant in the politically controversial war in Vietnam'. And J.D. Atkinson the ACB Chairman, noted (ACB 1977: 1) that the 'Motivation for this [proposed ban on 2,4,5-T] appeared to start during the Vietnam War...Since then anyone with a deformed child has grasped at this straw and blamed 2,4,5-T.'

Such an argument could partly be justified in that activism against the use of 2,4,5-T based military defoliants had been ongoing in the US since 1964, five years before dioxin became a public issue (Wildvasky 1995). Most prominent were several groups of scientists, including the American Association for the Advancement of Science (AAAS), which questioned whether the use of defoliants by the military constituted chemical warfare, and throughout the war it pressed for studies to determine the short- and long-term consequences of such use (Gough 1986; Primack & von Hippel 1974). Thus, when dioxin became a human and environmental health concern it is fair to surmise that the association the contaminant had with 2,4,5-T provided a degree of momentum for activists in the US (Whiteside 1970) and in New Zealand (Wilkes 1969).

However, as the remainder of the chapter discusses, while the early 1970s criticisms of 2,4,5-T and dioxins in New Zealand did occasionally refer to Agent Orange use and the Vietnam War, the *substance* and *motivation* of the arguments against dioxins were grounded in much wider concerns about technological risk and human safety. Dow's framing of anti-chemical sentiment as only emotional is better viewed as a political act meant to obscure the actual critiques that were being made. The dichotomies between objective/opinion, idealist/realist, emotion/knowledge and political/scientific that were typified in chemical industry statements acted to simplify the criticisms being made about dioxins and birth defects. Such criticisms, while sometimes infused with emotions and conviction, were still very much grounded in reasoned critique, rational logic and method. Polarising the rational and the emotional undermined these criticisms and simplified what were the complex precautionary arguments for and against dioxins.

The Agricultural Chemicals Board 1972 Subcommittee on 2,4,5-T

As noted in Chapter 6, two of the earliest critics about dioxin in New Zealand, university lecturers Robert Mann and Robert Elliot, had argued in print and on the radio in mid–late 1971 that exposure of mothers to contaminated 2,4,5-T during pregnancy might raise the potential for birth defects in their offspring. The media coverage of these arguments was mild and short-lived. This changed in early 1972 when a letter to the editor by two rural physicians was published in the *New Zealand Journal of Medicine* (Sare & Forbes 1972: 37–38). Entitled 'Possible dysmorphogenic effects of an agricultural chemical: 2,4,5-T' the letter reported that two babies born within a month of each other were afflicted with severe congenital birth defects that were incompatible with life. The mothers lived next to each other in Te Awamutu on hill country farms where 2,4,5-T had been used for several years.

Like Elliot and Mann the previous year, Sare and Forbes argued from a perspective that stressed the ability to quantify dioxin exposure. They offered calculations that suggested it was possible to be exposed to a birth-defect-causing dose of dioxin from aerially applied 2,4,5-T that drifted off-course, landed on a roof and was washed into the drinking water cistern. The doctors urged ‘any reader who knows of similar cases to make a report, so that the facts may all be correlated, and an official statement [from government] can be made’ (Sare & Forbes 1972: 38). The arguments of Sare and Forbes were phrased in the language of toxicology through discussions about ‘dose’ and assertions that their perspective was ‘based on scientific facts’ (1972: 38). These arguments could not be discounted easily, because the doctors, while self-proclaimed as ‘just small town GP’s’ (Sare 1972: 1), had positioned themselves as experts who were challenging the dominant view on its own terms.

The ACB responded to these allegations in early February and announced the formation of the ‘Subcommittee on 2,4,5-T’, specifically to investigate the birth defect claims of Sare and Forbes (Table 3). As a subcommittee of the ACB, its seven-person membership consisted of three representatives from agricultural interests. While the other members of the subcommittee were respected in their fields, they were not independent in the sense that two (Brewerton & McQueen) were advisors to the DOH, while the others were chosen by Allingham, the subcommittee chair.

Table 3 Membership of the April 1972 Agricultural Chemicals Board (ACB) Subcommittee on 2,4,5-T and their Recommendations for Immediate Restrictions

<table>
<tr><td colspan="2">

<u>Membership of the Subcommittee on 2,4,5-T</u>

P. Allingham, Chairman the Assistant Director, Division of Public Health, Department of Health.

G. Banfield, the Fields Superintendent, Department of Agriculture (DOA).

H. Brewerton, Chemistry Division, Department of Scientific and Industrial Research.

R. Elliot, Professor of Pediatrics, University of Auckland

D. Lake, the Veterinary Advisory Officer, DOA.

G. McQueen, the Director, National Poisons Information Centre.

B. Watts, Registrar, ACB.

</td></tr>
<tr><td><u>Uses</u></td><td>Withdraw all registrations of 2,4,5-T labelled specifically for and marketed for use in the environs of the home.

Cancel registration of the product used on apricots as a preharvest fruit-drop preventive.</td></tr>
<tr><td><u>Labels</u></td><td>A conspicuous warning to appear on all 2,4,5-T labels of those products not cancelled as follows:
   Warning- Women of child-bearing age should avoid exposure to 2,4,5-T.

Commercial packs to be labelled that use is not permitted in the environs of the home.

The presently required warning Ņavoid contamination of any public, domestic or private water supplyÓ to be emphasised.</td></tr>
<tr><td><u>TCDD level in 2,4,5-T</u></td><td>The subcommittee recommends that measures be put in train within the next 12 months to require that 2,4,5-T made available for use in New Zealand contain no more than 0.1 ppm TCDD.</td></tr>
<tr><td><u>Restrictions of aerial application</u></td><td>This subcommittee recommends that aerial application of 2,4,5-T be discouraged, but if such treatments are deemed to be essential, they be not made within one mile of a homestead or urban area.</td></tr>
</table>

Source: verbatim from ACB (1972c: 6-7)

This structuring of the subcommittee set firm discursive boundaries that predisposed and constrained the eventual findings. As noted in Chapter 2, similar interests are bound together into coherent groupings that Foucault called *disciplines*. In this case the ACB subcommittee was structured around the norms, ideals and aspirations of toxicology and agriculture. A discipline acts as an 'internal regulator of discourses' (Mills 1997: 69) that limits the types of knowledge considered real and what can count as a truth. In addition, disciplines give some subjects the exclusive right to comment on certain matters but not others: what Foucault described (1970: 11) as the idea 'that just anyone, in short, cannot speak of just anything'. While Sare and Forbes were medical professionals and had 'expert' status, their positioning was outside the disciplinary bounds of the ACB subcommittee.

Thus, the membership of the subcommittee and its findings allowed a rearticulation and defense of the toxicological approach to chemical governance that had already been constructed publicly during 1970–71 (Chapter 6). The ACB's subcommittee members met on February 25, 1972 and by April 4 their recommendations to the ACB were publicly announced (ACB 1972c) (Table 3). These recommendations were similar to those that had been legislated in 1970 by other countries (Table 2).

The first was the acceptable dose discourse for dioxins that had been argued for at the US Hart Hearings (Chapter 5). In assessing the potential for dioxins to cause birth defects in humans, the subcommittee relied on chemical industry assurances that dioxin levels were strictly maintained at 1 ppm in 2,4,5-T, and that 0.1 ppm would be the level by 1973 (Table 7.1). The subcommittee also based its recommendations on an emerging body of work that was assessing the dose–response of laboratory animals to dioxins. These studies involved feeding prescribed amounts of dioxin – usually expressed in milligrams of dioxin per kilogram of weight per day, or 'mg/Kg/day' – during certain stages of pregnancy. Toxicologists then factored this dose at which various birth defects appeared, with safety margins worked out between the test species and humans, to arrive at an acceptable daily dose of dioxins. Such studies had been conducted on dioxins since the late 1960s, and while debate existed about whether lab animal results could be relied upon as the basis for determining human safety factors, ethics precluded human experiments (ACB 1972b,c).

The second toxicological tool that was relied upon was the determination of *expected real-world exposure*. Typically, such exposure is calculated by estimating

> how much of a pesticide will land on a person's skin, how much of a person's skin will be exposed, how much of that pesticide will be absorbed into the body, how much will land on food plants, how long pesticide residues will remain on the plants, how many vegetables or fruits the person will eat in how much time, how much will land in water, how quickly the pesticide will break down in water, how much water the person will drink before the pesticide is broken down, and much the person weighs. (O'Brien 2000: 118)

For the 1972 subcommittee report on the cases that Sare and Forbes had documented, the ACB (1972c: 4) produced figures for possible roof-borne exposure and concluded that

> ...there was no contamination of the farm water supply by aerial drop or drift on to the roofs of the houses, but that two women were physically contaminated with 2,4,5-T while assisting [their husbands] in the spraying operations.

However, in the ACB press release for the subcommittee's report (1972c: 8), D. Becroft, a 'leading New Zealand pathologist', stated that such exposure was not a public health concern, as

> There is a very wide safety margin in the present use of 2,4,5-T in relation to the known effects on animals. A very obvious accident would be required to give significant human exposure, and there is no possibility of harm from hand spraying, skin contact, "drift", "a smell of spray in the air" and similar remote exposure.

Summary

Thus dioxin was readily acknowledged as a powerful teratogen. However, the committee postulated that human exposure to dioxins was minimal and could not under normal conditions approach the dose required to elicit birth defects. As with the arguments over food and water restrictions for 2,4,5-T described in Chapter 6, the existence of uncertainties and the availability of only a very limited amount of research to be drawn on did not feature strongly in the subcommittee's private debates or in its public statements.

The 1972 subcommittee report acted to limit oppositional discourses such as those of Sares and Forbes by a process of repetition of the key and canonical arguments underpinning toxicology. This process of commentary keeps the dominant discourses in circulation and excludes space for other ideas. While a seemingly mundane practice, repetition of similar ideas at different times is powerful as it 'says for the first time what has already been said' (Sheridan 1980: 124-125) and contributes to certain discourses becoming normalised.

Contesting birth defects: epidemiology and monitoring

Although not as widely covered as the concepts of acceptable dose and toxicity by the media at the time, the ACB subcommittee report (1972c: 8) had two 'Recommendations for further investigation' in addition to those presented in Table 7.1. These included:

> 1. Records of Deformities: Although records of numbers and types of deformities are available from the Department of Health, a further study of the epidemiology should be undertaken with particular reference to rural/urban ratios.
>
> 2. Further Investigations: The Departments of Health and Agriculture...[should] investigate those cases where persons have written either to members of the panel or to Doctors Sare and Forbes and where it has been alleged that the use of 2,4,5-T may be a factor in birth deformities reported.

This approach was based on the use of epidemiology and birth defect monitoring, which differ from toxicological-based approaches in that they focus on observations of natural experiments occurring in the real world, instead of laboratory results (Clapp & Ozonoff 2004: 201). This section examines how two entities, the Environmental Defence Society (EDS) and the New Zealand Commissioner for the Environment (CFE), critiqued this approach to understanding birth defect–dioxin relationships between 1972 and 1977. In doing so, it provides insight into how their oppositional discourses were not based on 'only emotional' arguments, but instead were composed of complex critiques that questioned what was becoming the dominant approach to chemical governance.

The EDS, still active today, was incorporated as a society in early 1971 and was 'committed to the preservation, restoration and rational use of the environment' (EDS

1972: 2). The group prided itself on its professional membership and its grounding in legal principles and science:

> EDS is made up of lawyers, scientists, town planners, students and other citizens committed to the preservation, restoration, and rational use of the environment. Using the skills of scientists, planners and other environmental experts, EDS assures that positions taken are thoroughly supported by scientific evidence. (EDS 1972: 2)

While the 1972 ACB subcommittee did not seek public submissions, the EDS submitted a lengthy petition calling for the banning of 2,4,5-T (EDS 1972). It requested either an immediate banning of 2,4,5-T or a six month period of prohibited use so that the herbicide could be reassessed. Similar to Wellford's often-quoted (Wade 1971: 312) assertion in the US that the 2,4,5-T/dioxin controversy symbolised 'a battleground of opposing philosophies about the relationship between technological risk and human safety' (Chapter 5), the EDS (1972: 2–3) framed its critiques around similar notions that differing degrees of proof existed, but were being ignored by the ACB:

> While the question of the public health and safety is the primary issue in the 2,4,5-T controversy there are a number of crucial underlying issues which make 2,4,5-T a test case of great significance. In the first place, it can be seen as a conflict between different points of view....the issue raises the question of the "burden of proof" in relation to dangerous chemicals....If new evidence is discovered casting doubt on the safety of a registered agricultural chemical, should the onus then be on the manufacturers to establish again that the agricultural chemical is safe or is the onus on the critics of the chemical to prove that the chemical is unsafe?

As part of this argument about proof, the EDS suggested (1972: 4) that the ACB's approach to birth defect monitoring and epidemiology outlined in the 1972 subcommittee report might struggle to detect causative factors of birth defects in human populations:

> It [would be]...highly misleading to claim that lack of proof from epidemiology shows that commercial 2,4,5-T is not teratogenic; the truth is that this method is incapable of detecting even some serious positive effects, and therefore a null result from it is inconclusive....Furthermore, statements that there is no evidence that humans have been harmed by 2,4,5-T mislead the public in that they imply reliable statistics exist on which pregnant women got exposed to 2,4,5-T and which bore defective babies, whereas in fact the New Zealand Government keeps no records on the former and possesses only incomplete statistics on the latter.

A similar criticism, that epidemiology would be incapable of detecting birth defects from dioxins, was also being put to the ACB subcommittee by DOH officials. On March 27, 1972, one week before the ACB report was publicly released, an unnamed DOH official wrote a memo about the subcommittee's proposal to recommend that epidemiology and birth defect monitoring be undertaken to better understand dioxins. The official noted (DOH 1972b: 1) that

> On page eight, under recommendations for further investigations...is an item relevant to our Department. There are two aspects of this which need to be considered...[including] the validity of the collection of these statistics, which are *voluntary* notifications on form H 665.... [Previous analysis] indicates there is not even a constant bias in these figures, which would therefore make it difficult to detect even a trend.... In the light of the above it is recommended that the gathering of these statistics from maternity hospitals be reviewed, to obtain a better coverage than at present. (emphasis added)

The EDS and DOH criticisms foreshadowed how the epidemiological studies looking at dioxin–birth defect connections in New Zealand would be hampered by a lack of adequate data. As will be explained next, the system for submitting birth defect notifications was voluntary, and therefore it was undersubscribed with many hospitals submitting monthly records sporadically or not at all. This resulted in an incomplete nationwide data set that until the early 1980s essentially could not produce any valid indications of birth defect patterns (DOH 1992).

Despite the DOH and EDS comments, the 1972 ACB subcommittee's recommendations were approved and epidemiology and birth defect monitoring became a part of the government's approach to dioxins. After the subcommittee report, which called for people to report suspect birth defects, the DOH began to receive reports about human and farm animal birth defects from around the country. By September, the ACB reported that the DOH had completed 16 investigations where women felt that 2,4,5-T had contributed to deformities in their children (ACB 1972b). From 1973 to mid-1976, a similar number of birth defects were reported to the DOH and investigated. The DOH-led investigations consisted of the local Medical Officer of Health (MOOH) visiting the affected family and conducting an interview that focused, amongst other things, on determining what if any exposures to 2,4,5-T could have occurred, whether the family had a history of congenital abnormalities and whether any drugs had been taken during the pregnancy. A local Department of Agriculture Farm Advisory Officer would accompany the MOOH and would inquire about local spraying regimes including the times and methods of applications, and the quantities and type of chemicals used (DOH 1977a). This information was then reported back to the Department of Health head office in Wellington to be analysed.

Despite this reporting and the attention given to some of these reports in the media, overall the public's attention to dioxin–birth defect issues faded considerably from mid-1972 until 1976. Government and chemical industry assurances about dioxin dose and exposure potential seemed to ease public concern. During this period, DOH investigations did not produce any results that warranted further attention. In all cases, officials concluded that the potential dose of dioxin that mothers might have been exposed to was inconsequential in relation to being able to cause a birth defect. Further, available DOH files do not contain any evidence that the reported birth defects were analysed in relation to overall rates of birth defects throughout New Zealand. Such comparisons, recommended in the 1972 ACB subcommittee report, would not become an issue again until late-1976.

Several events coalesced from mid-1976 through 1977 that caused the birth defects–dioxin issue to again become very prominent in New Zealand. First was the July 10, 1976 explosion at a Hoffman-LaRoche TCP production facility in Seveso, Italy. A reactor vessel containing TCP overheated, releasing a plume of chemical vapour through an exhaust vent and into the atmosphere (Thornton 2000: 271). Approximately two kilograms of TCDD was deposited in the immediate vicinity of the plant. Eventually, 18 square kilometers were considered contaminated and 37,000 people had received some degree of dioxin exposure (Gibbs 1995: 101). The accident is considered the largest single event exposure to a residential population of dioxins (Eskenazai et al. 2004).

Similar large-scale accidents had occurred at TCP plants in the past, including in Nitro, West Virginia, USA (1949, Monsanto); Ludwigshafen am Rhein, West Germany (1953, BASF); Amsterdam (1963, Philips Duphar); and Bolsover, Derbyshire, England (1968, Coalite) (Whiteside 1979). After the Seveso accident, the DOH began a series of meetings with IWD and the company moved to reassure the government and the public that the TCP process used at their New Plymouth plant was fundamentally different and such an accident was not possible (DOH 1976a, b).

The concerns over Seveso were amplified during late 1976 and early 1977 by reports of several clusters of birth defects around New Zealand potentially related to 2,4,5-T exposure. A physician at Harewa Hospital, Taranaki noticed that four babies born over the previous two and half years from two streets in Opunake were afflicted with similar birth defects (anencephaly) (DOH New Plymouth 1977). A doctor at Waikato Hospital, Hamilton reported that in a one month period in December 1975 to January 1976, eight cases of neural tube birth defects had been observed. And in Whangarei, eight birth defects during 1976 were reported (DOH Whangarei 1977). All of these reports were completed by local Medical Officers of Health who then forwarded to the DOH head office in Wellington.

In late 1976 when the DOH began to investigate these reports, the CFE became involved in dioxin issues. The CFE was the predecessor to what is now the Parliamentary Commissioner for the Environment and was established in 1972 following the United Nations Stockholm Conference on the Human Environment. The CFE, A.J. Brunt, had received letters from several people in Whangarei who expressed concern about locally occurring birth defects.

Brunt initially contacted the head of the National Health Statistics Centre and inquired about whether any statistical work, including the comparison of urban to rural ratios of birth defects called for by the 1972 ACB subcommittee report, had been carried out and whether the Centre had found any results of significance (CFE 1976). Frank Foster, the Head of the Statistics Centre, 'seemed unaware of the 1972 recommendations of the ACB' (CFE 1976: 3), and informed Brunt that no such analysis had been carried out, but that they would start such an analysis soon. However, shortly after this, a CFE memo (1977: 2) reported that

> The statistical centre has now indicated that it is not doing a national assessment of the rural/urban incidence of spina bifida, because this is a major exercise and the inadequate reporting of birth defect statistics would make such an anlaysis of doubtful value.

Brunt began to press the DOH to clarify the role of birth defect monitoring and epidemiological studies of dioxin exposures if such analysis was not going to be done (CFE 1977). He also began to canvas local MOOHs to assess whether they were carrying out adequate investigations. Several indicated that while they conducted the investigations, they felt such work was superfluous. For instance, the MOOH from Whangarei (1977: 1) noted that

> The present small study in Northland has little epidemiological value....In my opinion only epidemiological studies including macro-analysis on a national scale over a period of time associated with international studies could indicate if spina bifida has increased in recent years correlated to the local use of 2,4,5-T. Small micro-analysis studies can be most misleading.

Brunt also observed that many MOOH did not treat their investigations 'with any sense of urgency', and thus he concluded (CFE 1977: 2) that

> A detailed investigation of...[birth defect] clusters...by several officers from the head office might be more appropriate than relying on hard pressed medical officers of health. It seems, for example, that Dr. Gordon did not set interviewing in train in the Waikato because he did not have the time or the local officers to invest in such a time-consuming affair.

Brunt's criticisms appear to have remained private between his office and the DOH, as these criticisms were not widely covered in the media. During the first half of 1977 the DOH began to clarify why birth defect monitoring and epidemiology were not providing useful information. In late February 1977, a controversial 'Dateline' television documentary was to air, detailing the Opunake, Whangarei and Hamilton birth defect clusters. To prepare for public reactions, the DOH sent to all MOOH a detailed memo entitled ‘Departmental attitude to date on 2,4,5-T’ (DOH 1977a). In explaining the failings of the birth defect monitoring, the DOH (1977a: 3) noted that

> The small number of open neural tube defects occurring in New Zealand (about 2 per 1,000 live births) and the multiplicity of causative influences necessitates the establishment of a register to identify all cases, if epidemiological studies are to be meaningful. Provision for such a congenital deformities register was made in 1972 during the drafting of the revised Obstetric Regulations. Revision of these regulations was unusually slow, with them eventually coming into force on 1 July 1975. Some aspects of the notification form were not acceptable, in spite of prior consultation with the medical profession, and returns were not always completed. The contentious section was then removed from the notification form from 1 December 1976 and it is anticipated that notification of congenital abnormalities will now proceed....The New Zealand experience [of congenital abnormalities] cannot be accurately determined until a complete register return is achieved.

Thus, a nationwide system of monitoring birth defects was not in place until 1975, while inadequacies in the form resulted in many districts not even submitting their results.

In reaction to the ‘Dateline’ documentary and the birth defects in Opunake, Whangarei and Hamilton, the DOH conducted a study, the findings of which were released in June 1977 as the *2,4,5-T and Human Birth Defects* report (DOH 1977b). The report did not call for any new restrictions on 2,4,5-T. However it did acknowledge some of the limitations of birth defect monitoring in New Zealand and the uncertainties inherent in determining a casual factor because of statistical variability and small sample sizes. It stated:

> ...in some cases it is not possible to identify any particular causal factor from these investigations. Considering the number of highly sophisticated and well-designed surveys that have not been able to isolate an environmental cause for neural tube defects this is hardly surprising (DOH 1977b: 35).

In concluding, the report highlighted the gap that existed between the rationalistic frameworks of toxicology and epidemiology and those calling for more precautionary approaches to managing dioxins. The report (DOH 1977b: 35-36) noted that

> In short, the data permit the conclusion that there is not evidence to implicate 2,4,5-T as a casual factor in human birth defects. This statement, although scientifically correct, is unfortunately commonly misunderstood by the public and even some scientists. The demand is usually for ‘proof of safety’ and a statement that there is no evidence for harm is unsatisfactory for many. It must be faced that there is no way in which <u>any</u> substance...can ever be proved absolutely safe. To achieve such a standard of proof would entail testing every person with every substance at every conceivable exposure level in every imaginable circumstance....The best that can be achieved for any substance is a high degree of ‘assurance’ of safety based upon a rational and experienced scientific judgment of the available evidence. The accumulated data on 2,4,5-T and its TCDD contaminant are sufficient to give a very high assurance of safety in the normal use of this material. This belief is in accordance with the consensus of world-wide scientific opinion.

The DOH’s descriptions of anti-chemical sentiment as demanding a seemingly unattainable proof of safety unfortunately acted to polarise the precautionary and the rationalistic approaches to chemical governance. The critiques by the PCE and the EDS were centered on acknowledging the uncertainty, not on demands for absolute safety. The DOH assertion that a ‘high degree of assurance’ was possible for understanding the distribution of birth defects and their causes was untrue, as sufficient data that would allow such judgments was not available.

Conclusions

The New Zealand experience with birth defect monitoring, and subsequent epidemiological studies to understand the results of such monitoring, were not unique. Most industrialised countries did not have adequate monitoring systems in place until the late 1970s. Effective monitoring and subsequent epidemiological understanding requires not only the ability to identify causative factors (such as drugs and chemicals) and to be able to distinguish them from other variables, but also an understanding of what the 'normal' background levels of birth defects are in given areas (Clapp & Ozonoff 2004). New Zealand was not able to provide such information in a statistically robust way during the 1970s.

The EDS and later the CFE attempted to highlight how the DOH's approach to epidemiology was flawed and would not be able to detect birth defect trends sufficiently. In contrast to the 'only emotional' construction that was attached to those forwarding oppositional discourses, their arguments were grounded in the very scientific methodologies they were critiquing. However, this criticism did not become an effective oppositional discourse. This is partly because the critiques involved complex methodological issues that were not understood publicly with the same ease as the acceptable dose discourse.

In the case of the CFE, it appears that they regarded their role as more an *internal* critic of government. The CFE communicated extensively with the DOH, offering their opinions and suggestions on how the DOH might approach birth defect monitoring. However, the places in which they identified flaws were not communicated to other groups or to society in general. The EDS and CFE also lacked public standing as insiders in the disciplinary realm of toxicology and agriculture. Thus, these insightful critiques of the government approach to birth defects monitoring did not become circulated and repeated in the same way that the acceptable dose discourse did.

Chapter 8 The inadequacies of local environmental (in)justice resolution by science alone: understanding the past and present silences of dioxins

This chapter focuses on New Plymouth, the place where the majority of 2,4,5-T used in New Zealand was produced, and where the present-day dioxin controversies have received the most attention from government. The first section examines the historical production of 2,4,5-T and its associated wastes in New Plymouth. It argues that the discursive construction of, and resistance to, the chemical promise outlined in the previous chapters in many ways obscured and silenced these local manifestations of dioxins. The second section briefly details the broad contours of dioxin politics during the late 1970s through to the 1990s. It argues that many of the issues silenced in New Plymouth during the 1970s became part of a nationwide awakening to the extent of hazardous waste problems and their undermining of the chemical promise. The third section discusses the recent (1999–2007) focus on human contamination by dioxins in New Plymouth. It argues that while science has allowed the effects of dioxins on humans to become visible, resolving contemporary dioxin grievances ultimately will require addressing socio-historic issues.

Dioxin waste and the silencing of Paritutu

Ivon Watkins (IW) operated as a small business out of several premises in New Plymouth during the 1940s and 1950s (Chapter 4). Its main manufacturing plant was located at 14–24 Buller Street in downtown New Plymouth. However, because of a lack of suitable buildings and the slow rate at which the business had grown initially, it also had offices, storage and other operations occurring at four other locations in this period (IW 1959c). During the late 1950s, IW was enjoying a period of sustained growth, both in volume of existing product sales, and in the launching of new agro- and industrial-chemical products (IW 1959e). This rapid growth was putting strains on the ability of the company to operate effectively out of its scattered and dated facilities. In early 1959, the Taranaki Harbour Board decided to develop a large portion of land under its control, at Paritutu (also known as Spotswood) on the western outskirts of New Plymouth (Boshier & Boland 1992: 26) (Figure 11). The development was intended to be primarily industrial, and IW became the first company to invest in the area. It secured a long-term lease of 3.1 hectares and began construction of its new plant in mid-1959.

Figure 11 Map of western New Plymouth showing the location of the DowAgroSciences (NZ) Ltd/IWD factory and surrounding neighbourhoods (*Source*: TUMONZ version 3.0)

The plant was officially opened on November 24, 1960 and was heralded as the largest and most modern agricultural chemical manufacturing plant in New Zealand. Just prior to the opening, IW officials noted that ‘New Plymouth has become recognised as a pleasant place to work and live in, and in every way the directors of IW plan that their factory will satisfy regional opinion’ (IW 1959c: 5). Similarly, a 1960 handwritten memo by a local health officer conducting an inspection of the IW plant for compliance with the Noxious Substances Regulations noted that the factory was ‘ideally situated’ (Taranaki District Health Board [TDHB] 1960).These optimistic perspectives have been challenged over the last 45 years by two related factors.

First, has been the close proximity of residential housing to the chemical plant. Residential subdivision had been occurring in the Paritutu and Ngamotu Road area since 1948, and when the company began construction, several dozen houses already existed adjacent to the southern factory boundary (Boshier & Boland 1992). Further subdivision occurred throughout the 1960s and ‘70s, much of it devoted to providing housing for employees of the electricity and petroleum industries that shared with Ivon Watkins-Dow (IWD) in the development of the Harbour Board’s lands. In 1967, the New Plymouth City Council allowed the Harbour Board to rezone an area of residential land to the south of the plant for industrial use, allowing for the expansion of IW activities, and reducing the buffer between some houses and the manufacturing plant to approximately 200 metres (Boshier & Boland 1992) (Figures 12 & 13).

Figure 12 Early 1960s aerial photo of the Ivon Watkins factory (*Source*: activist collection

Figure 13 2004 view of the DowAgroSciences (NZ) Ltd. plant and the neighbourhood of Paritutu (*Source*: picture taken by Bruce Wildblood-Crawford)

The second factor that has complicated IWD's vision of satisfying regional opinion has been the production and dissemination of chemical waste products. These have included fugitive aerial emissions from the plant and solid and liquid wastes disposed of through various methods in different locations around New Plymouth. As will be explained shortly, these wastes, and the close proximity of the plant to residential housing, have resulted in a series of disputes about the potential human health effects of exposure to chemical pollutants. In exploring how these two factors and the resulting disputes have informed the dioxin controversy, it is useful to initially group them into two distinct periods: before the emergence of dioxin as a public issue (in late 1969) and post-1970.

The first complaints about the IWD plant in New Plymouth that have been recorded in newspapers and government archives began in mid-1964. These complaints revolved around fugitive aerial emissions, which are airborne emissions that leave the plant through vents, windows and other openings. While the archival records of this period are sparse, the letters written by Paritutu residents to the Department of Health (DOH) give some indication of the extent of fugitive emissions from the plant. One letter noted that 'with any westerly wind the smell from Watkins-Dow crawls over us' (Anonymous 1964a: 1), while another (Anonymous 1964b: 1) described a period of sustained emissions:

> In the last few days, with the wind from the northwest, the smell from the Watkins chemical manufactures was and is terrible. On waking up about the middle of the night, it is so foul it makes us feel sick and gives us bad headaches. Surely this should not be allowed so near human beings.

The DOH Head Office, Wellington, instructed the New Plymouth Medical Officer of Health to investigate these complaints. In correspondence with the Medical Officer of

Health and the DOH, IWD noted that it had not changed any processes recently that could account for the increased complaints of foul smells, although it had experienced some problems with a scrubber system designed to reduce aerial emissions (DOH New Plymouth 1964). In summarising their investigation, the New Plymouth Medical Officer of Health concluded that the complaints were the result of a blocked exhaust gas filter, a period of prolonged westerly winds and 'anxiety' on the part of the locals who 'were afraid of the odour containing poisonous components' (DOH New Plymouth 1964: 1-2). Thus the DOH responded to the complaints and engaged with IWD to resolve what became termed the 'odour control problem'. However, the air emissions from the plant were not then regulated or monitored under any existing legislation so in effect the attempted curtailing of fugitive emissions by IWD was voluntary (Baker et al. 2003: 4). This was remedied to a certain degree by the Clean Air Act (1972), which brought stricter controls on such emissions.

Besides air emissions, complaints about chemically contaminated storm-water and sewage being piped out of the IWD facility into the ocean and onto sand-hills adjacent to the plant were raised in late-1967 and again in the early 1970s. Local residents complained that birds were dying in Centennial Park, a beach area that contained several council-approved IWD outfall pipes. However, because of the substantial silence in the government records for this period (Chapter 3), it is unclear how these complaints were addressed.

From the scarce amount of information available, it is apparent that complaints about localised pollution from the IWD plant during the 1960s attracted some attention. However, the concern that was generated appears to have been minimal. The reporting of these incidences and the approach taken by government did not call into question the wastes being generated per se, or the close proximity of the plant to residential areas. Instead, the waste issues were largely constructed as minor public issues that could be remedied by improving the technical operations at the plant.

The remainder of this section will discuss how local sentiment did not change in the 1970s, despite the emergence of dioxin as a public issue and a greater consciousness around issues of toxic pollution. While sustained debate occurred nationally and internationally over dioxin limits in 2,4,5-T and how they might have been causing birth defects, the potential for harm from the IWD plant in Paritutu did not become part of the dominant dioxin narratives in New Zealand (Chapters 5–7). It is argued that this local silence in New Plymouth was perpetuated by both the mundane and complex nature of chemical wastes, and also by the way dioxin issues were constantly being constructed through interactions with other, non-local spaces.

Disposal of dioxin-contaminated waste in New Plymouth post-1970

The production of dioxin contaminated solid and liquid wastes at IWD's Paritutu plant likely started with the beginning of 2,4,5-T manufacture in 1962. As discussed in Chapter 5, dioxin was formed in the manufacture of TCP, a precursor ingredient to 2,4,5-T. Up until late 1969, IWD imported TCP, and hence dioxin, into New Zealand. The extent to which IWD's use of imported TCP to manufacture 2,4,5-T resulted in local dioxin-contaminated wastes, and what happened to these wastes, are unknown. From late 1969, IWD began to manufacture its own TCP. This process would have resulted in a much higher volume of solid and liquid wastes contaminated with dioxins, but again the details of this are not publicly known.

The type and quantities of dioxin wastes that are best understood are ironically those that were created through industry and government efforts to *lower* the dioxin content in commercial 2,4,5-T. The 0.1 parts per million (ppm) dioxin limit that was legislated in New Zealand in 1972 (Chapter 7) was achieved not by making less dioxin during the TCP process, but by extracting some of the dioxins out of the herbicide using solvents. Once the dioxins were extracted, creating a marketable product within the 0.1 ppm limit, the resulting solvent waste stream was stored in drums on-site at the IWD factory. IWD notified the DOH prior to the passing of the 1972 regulations that the 0.1 ppm limit would result in a high volume of liquid wastes and that the only practical means of disposal would be to incinerate the solvents (IWD 1972a). In mid-1973, the DOH issued a license under the Clean Air Act (1972) for IWD to operate a liquid incinerator onsite at the Paritutu factory, although the incinerator did not become operational until early 1975 (Boshier & Boland 1992). Between 1975 and 1979, 566,000 litres of dioxin-contaminated solvents were incinerated during 16,600 hours of burning (Coster et al. 1986).

Besides incineration, other dioxin-contaminated manufacturing wastes were buried by IWD during the 1970s. Only two incidences of such burial have been publicly documented. Coster et al. (1986 :17) notes that 100 drums of sludge from the production of 2,4,5-T and 130 drums of waste from TCP production were buried in what was called the 'Ngahoro Landfill' in 1973. This burial site was located at the end of Beach Road in New Plymouth and was on a small parcel of land owned by the company. In addition, IWD owned a 37 ha property approximately 4 kms north of the IWD plant at Paritutu. It was known as the 'Waireka Experimental Farm' and was used by the company to trial new products and conduct research (Figure 14). In 1975 and 1976, IWD disposed of various wastes at two burial sites on the farm (Taranaki

Regional Council 2001a). This dumping was approved by the DOH at the time after an inspection was conducted at the site by the local Medical Officer of Health (DOH New Plymouth 1975). As was common practice at the time, no monitoring or specific conditions, such as lining the burial pit or installing a leachate collection system, were imposed by the DOH.

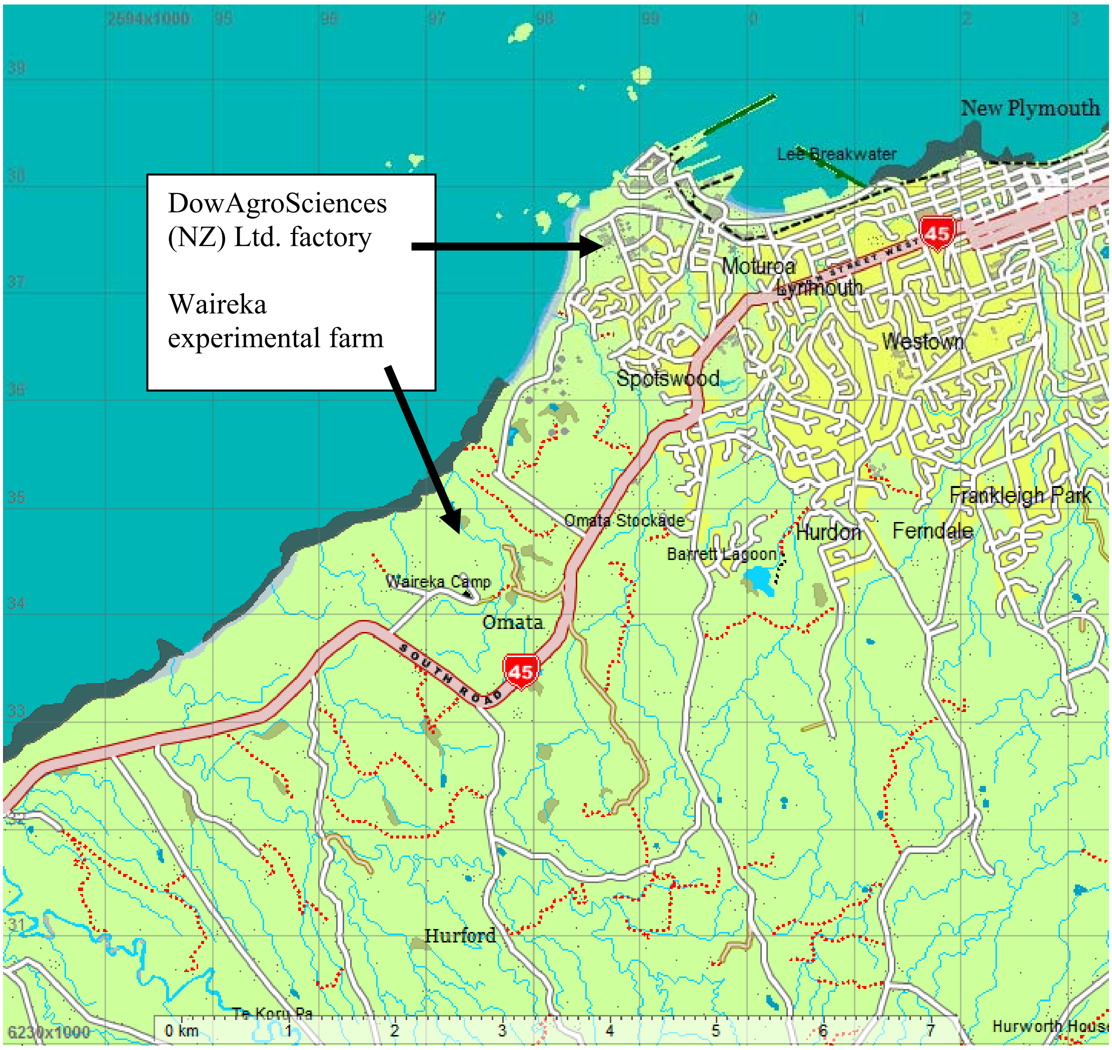


Figure 14 Map of western New Plymouth showing the location of the DowAgroSciences (NZ) Ltd/IWD factory and the company's Waireka experimental farm along the coast (*Source*: TUMONZ version 3.0)

Despite the sustained media attention that dioxins and IWD received during the 1970s, the waste disposal practices being carried out in New Plymouth attracted almost no attention from the media or anti-chemical social movements, even during the various peaks of interest in dioxins (Chapters 5–7). Several reasons, all interrelated, are likely to be responsible for this silence.

First was that the dominant public construction of early anti-chemical sentiment, which started in the 1960s with *Silent Spring* and the ban on DDT, was not directed at manufacturing processes per se, but at the effects of chemicals once released into the environment. Effects on wildlife and food crops were what elicited the most attention from media, social movements and regulatory agencies. It is argued here that this was in part because, as discussed in Chapter 5, mundane industrial processes were not widely understood by the general public or government, nor was knowledge about them widely available because industry was not required to disclose this information. Thus when the acceptable dose discourse of 1 ppm and eventually 0.1 ppm became a dominant discourse of the dioxin debate, interrogating how these limits would be obtained at the local manufacturing level, and what effects this might have on waste production, were not part of the broader critique against chemicals.

Second, as demonstrated in Chapters 5–7, the public and private construction of dioxin issues in New Zealand was being done primarily through interactions with, and reference to, a myriad of other spaces. Dioxins it seemed were everywhere except New Plymouth, being constantly made and remade through national and international discursive flows. For instance, the focus on birth defects occurring throughout New Zealand concentrated attention on the dissemination of dioxins through 2,4,5-T spraying in agriculture, without any critical attention to its origins. Similarly, the governance of dioxins through the acceptable dose discourse tended to highlight how other countries were managing the chemicals and how New Zealand was creating its own version of this governance. Thus the silence in New Plymouth was in many ways a symptom of governance through risk assessment: the initial creation of dioxins in the first place was accepted uncritically and the focus was on how to manage their dispersion and effects.

Several voices did attempt to draw attention to the issue of local pollution in Paritutu during the early 1970s. Ray Kennedy was a long-time Paritutu resident who lived one block from the IWD plant. In 1974, he ran a series of advertisements in local newspapers that asked people to sign a petition opposing the ‘vapour drift’ of hormone weedkillers emanating from the IWD plant. In 1975, Kennedy claimed that contaminated sewage from the production of 2,4,5-T and 2,4-D, had leaked out of the public stormwater system and flooded his yard, destroying his tomato gardens and grass lawn (Kennedy 1975). He sent numerous letters to IWD and the DOH, and his claims were covered for several months in the New Plymouth newspapers. In 1975, IWD offered to settle with Kennedy, never admitting liability, but stating they would pay to have his lawn resown (IWD 1975).

Owen Wilkes, a well-known New Zealand peace activist and writer, tried to draw attention to the possible connections between the national discourses about dioxins and birth defects, and the local production of 2,4,5-T in New Plymouth. In 1973, he wrote an article in the *NZ Monthly Review* (Wilkes 1973a) and sent letters to the DOH (Wilkes 1973b). He cited national birth defects statistics that showed New Plymouth had a disproportionately high incidence of birth defects compared with other regions of the country, and questioned whether these figures were the results of 2,4,5-T production.

The efforts of Kennedy and Wilkes to highlight how dioxins were affecting New Plymouth had little spin-off nationally. The public debate was firmly centred on birth defects, acceptable doses and management operating in and through other spaces. Discursive practices at other scales, in this case national and international, acted to both limit and silence the examination of local implications.

Dioxin politics during the late 1970s–1990s

This section provides a broad overview of the period from where Chapter 7 left off (mid-1970s) through to the beginning of the 1990s. While it is not possible to comprehensively detail all the history of this period, the following describes how many of the main actors and power/knowledge relationships established in the early 1970s would endure, as would the challenges to the chemical promise. The silencing of dioxin issues in New Plymouth would slowly disappear, as the waste issues of the 1970s would become more prominent and would form part of a wider critique of agrochemicals.

The dioxin controversy never really waned internationally or in New Zealand during the 1970s and '80s. In 1978, the US the EPA initiated a Rebuttable Presumption Registration (RPAR) process against 2,4,5-T, the first step towards permanently cancelling the use of the chemical. In 1979, the EPA instituted an emergency suspension of 2,4,5-T use in forests, rights of way, pasture, home/garden and water because of data that correlated spontaneous abortions with 2,4,5-T use in several areas in Oregon (Doyle 2004: 66). Known as the 'Alsea' studies, the statistical basis of these reports was widely challenged, both through US reports and Dow media releases, but also by the governments of New Zealand (DOH 1979; UK (Advisory Committee on Pesticides see Klapp 1992) and Australia (Australian National Health & Medical Research Council 1979). The EPA RPAR process went through a series of deliberations, before Dow USA withdrew its objections in 1982, citing the ongoing financial cost of the process. In 1983, Dow announced it would withdraw its registration of 2,4,5-T and no longer manufacture or market the chemical in the US.

Another prominent dioxin issue during this same late-1970s and 1980s period was the accusations by US Vietnam veterans that the use of Agent Orange was causing ill health. Several veterans' groups filed a class action lawsuit in 1979 against the manufacturers who had supplied chemical defoliants to the US military (Challinor & Lancaster 2000). After numerous legal proceedings, in 1984 the case was settled out of court for $180 million. During the same period, the US Congress passed the Veterans Health Programs Extension and Improvements Act of 1979, which instructed the government to conduct a large-scale epidemiological study of US veterans in relation to dioxin exposure. Throughout the 1980s, the results of these and other studies on veterans would not produce any clear directions about whether dioxins caused human health effects (US House of Representatives, Committee on Government Operations 1990).

In New Zealand, the US RPAR process was discounted by the ACB and the DOH as not producing any new information that would change their long-held views that 2,4,5-T containing a minimal level of dioxin was safe. However, what did change considerably was that the silence in New Plymouth slowly began to fade and the issues concerning the IWD plant began to become prominent nationally. In 1980, the NZ Food Processing and Chemical Union (NZFPCU), responding to pressure from its members, requested that the DOH conduct a study on worker health at IWD (NZFPCU 1980). While the study, released in September 1980, found workers to be generally healthy, it raised awareness about a group that previously had not featured widely in the dioxin controversy.

Waste disposal issues again become prominent, in part because of the burial practices of the 1970s and because of the continued production of high volumes of dioxin-contaminated residues and materials. In February 1980, IWD exhumed the wastes it had buried at the Ngahoro site in order to be able to sell the land. The recovered wastes were returned to the factory where they were 'reprocessed or incinerated' (Taranaki Regional Council 2001b). In December 1982, a member of the public noticed a steady flow of 'chemical smelling seepage' coming out of the hill along the beach near IWD's Waireka farm (Taranaki Regional Council 2001b). In early 1983, with approximately 400 litres of chemical waste leaking out of the site per week (DOH 1983), IWD installed a leachate collection and treatment station at the site. By November 1983, IWD reported two more leaks along the same hill and the DOH informed the company that the existing 'dump was no longer acceptable' (TDHB 1983: 1). In 1985, IWD began digging up all of the old burial site and transferring the contents into a new, securely lined landfill at its Waireka farm.

The Waireka dump issue, widely covered in the media, had been preceded by the 1983 installation at Paritutu of a solid-waste incinerator that began burning off-spec chemicals, contaminated steel drums and sludge that had been accumulating at the plant. Further to this, in 1982 the New Zealand government had lowered the acceptable dioxin level in 2,4,5-T from 0.1 to 0.01 ppm. This required even more solvent extraction and distillation than the prior limit, and resulted in 10 tonnes of additional solvent residues each year that required incineration.

The waste issues surrounding the operation of IWD during the early 1980s did not feature in at least one prominent narrative of the area. The Waitangi Tribunal was established in 1975 as a permanent commission of inquiry to address claims by Maori relating to breaches of the Treaty of Waitangi (1840). A March 1983 report (Taylor 1983) concerning Te Atiawa Treaty claims noted that the widespread industrial development in the Paritutu area, including the Motunui synthetic fuels plant, Port Taranaki, the power station, and the oxidation ponds, were all potential sources of coastal pollution. However, IWD was not included in the report, despite the immediate vicinity of the plant to these other industrial sites.

In 1985, Residents Against Dioxins (RAD) was formed by residents in New Plymouth concerned about the dump mishaps of the previous five years and the extent of ongoing incineration. Greenpeace New Zealand began to work with RAD, and a large letter writing campaign against IWD was started. Fortuitously for RAD and other groups arguing that 2,4,5-T production should cease, the IWD factory suffered a serious explosion. On April 15, 1985, a TCP reactor vessel overheated and a bursting disc failed, resulting in a rupture to the tank and the release of 1415 kilograms of liquid reactor material into the factory, including an estimated 1 kilogram of dioxin. Substantial vapours from the explosion also escaped from the plant as fugitive emissions. While the reactor vessel area was decontaminated quickly, the public relations damage was substantial and the concerns of RAD quickly became national news. In early 1986, the report, *The Use of 2,4,5-T in New Zealand: A Report to the Environmental Council* (Coster et al.) was released. Amongst eight recommendations was one that called for a moratorium on the production of TCP and 2,4,5-T until more research was done. Further, on June 24, 1986 the DOH established the Ministerial Committee of Inquiry to Advise on the Impact on the Health of the Residents in New

Plymouth from the Manufacture of Pesticides. Known as the Brinkman Inquiry, its report concluded that the 1985 accident, and historic 2,4,5-T production had caused no health effects amongst local residents (Brinkman 1986, 1987).

Despite the Brinkman report, the pressure on IWD to cease 2,4,5-T production was steady. New Zealand was both the highest per capita user of the revolutionary herbicide, and was also one of the last countries in the world to use it extensively (Brinkman 1986). In August 1987, IWD announced that production of 2,4,5-T would cease by the end of the year, while existing stocks of the herbicide would remain on sale until December 1988 (Syme 1988: 1). Tony Jacques, public relations manager for IWD explained (Easton 1988: 1) that the decision was made easier by the recent successful trials of a 2,4,5-T replacement called Grazon:

> We felt as a company that we could live with the bad publicity (about 2,4,5-T) but we felt we could not live with a commercial uncertainty...We had no uncertainty about 2,4,5-T...but we had to recognise that the product was potentially liable to be withdrawn from the market for reasons which were not scientific. When a new product [triclopyer/Grazon] was recognised, we had to ask whether it was worth it to stay with 2,4,5-T.

The end of 2,4,5-T production in New Plymouth can at one level be viewed as the end of the chemical promise. However, chemical use in agriculture did not fade. While the high volumes of subsidised and low cost 2,4,5-T would be replaced by more expensive substitutes such as Grazon, agrochemical use continued. In addition, the years of debate and emerging evidence that dioxins were harmful to health, had in many ways done little to challenge the chemical promise in some minds. In responding to a letter about continued 2,4,5-T use, then Minister of Health, Michael Bassett (1987: 1) insisted that the writer remember that

> fertilisers and pesticides have brought great benefits to the world during the latter half of this century by increasing the quantity and quality of agricultural output. New Zealand depends for its [sic] economic survival largely on the export of products from its farms. To stop using these chemicals would not only greatly reduce the quantity of production, but also lead to a low quality which would be unacceptable to most overseas markets.

The 1990s and beyond

The cessation of 2,4,5-T production and use resulted in a period of relative calm in the dioxin controversy. However, this respite was short-lived. During the 1990s, dioxins became one of many chemicals focused on by the public. Dann (2003: 278) has noted that 'most of the environmental damage from industrial agriculture is invisible.' However, during the 1990s the damage caused by agrochemical use became visible in several ways.

First, New Zealand's landmark 1991 Resource Management Act (RMA) redefined the roles that territorial local authorities and regional councils have in managing hazardous wastes. The RMA requires regional councils to control the use of land to 'prevent or mitigate adverse effects from the storage, use and disposal of hazardous substances' (Ministry for the Environment 2006b: 4). While the level of attention to such substances varied amongst councils, during the 1990s many conducted region-wide surveys and large collections of old agrochemicals for safe disposal.

As part of their responsibilities under the RMA, regional councils and central government also began to focus more on the issue of contaminated land. Former timber treatment sites and sawmills were one of the earliest foci of attention in this respect. In 1990, a National Task Group (NTG) was set up to assess the extent and potential threat of sawmill and timber treatment sites. The NTG report (1992) estimated that there were around 7500 contaminated sites across New Zealand. Waipa Mill, outside the popular tourist attraction of Rotorua, was selected for detailed study. The high levels of PCP contamination onsite at the mill were subsequently found to have affected nearby Lake Rotorua, resulting in recommendations to eat only limited quantities of fish from the lake (Camp Scott Furphy 1992).

Also during 1992, the Parliamentary Commissioner for the Environment (PCE) published a report entitled *The Management of Hazardous Wastes Disposal: A Review of Government Systems* (Boshier & Boland 1992). The PCE began her investigations leading to the report after the persistent letter writing of Frances George. George, who lives in Manaia, south of New Plymouth, had outlined a series of concerns about the IWD operation in Paritutu. In particular, she focused on the continued incineration of chemical wastes at the factory and her belief that government was negligent in managing the emissions (George 1991a, b). The PCE report focused on the relationship between IWD and the DOH, and how they approached managing hazardous waste. The report (Boshier & Boland 1992: vi-vii) concluded, among other things, that

> The [IWD] case study has illustrated limitations in the Government system for the control of hazardous waste disposal. These limitations primarily relate to legislation that was previously in place and the lack of monitoring of the effects of the emissions... There is insufficient information on the nature and quantities of hazardous materials generated or disposed of in New Zealand... [In addition], a national policy on waste minimisation for hazardous wastes should be developed and coordinated.

While these reports received considerable national coverage, their impact was minimal compared with the ramifications of a single article published in the *New Scientist* in 1993. Entitled 'New Zealand's Poisoned Paradise', the article by Michael Szabo (1993:

29) claimed that ‘agriculture, forestry and industry have left a legacy of toxic waste’ in the country that could not be ignored. This claim, widely covered internationally, became an important political issue nationally because it undermined and challenged the ‘clean and green’ image of New Zealand. This image has served as a core tenet of national identity (Bell 1996), and during the 1990s it was becoming a central way the country was branding itself for tourism and trade. The latter reason in particular evoked a strong response from the New Zealand government. Writing in an editorial in the *New Scientist*, W. Rob Storey, the Minister for the Environment wrote (1993: 46) that

> ...New Zealand is clean and green. There are no poisonous chemical waste dumps lurking behind every picturesque scene. The few–very few–possible problem sites we do have, left over from a past, less environmentally aware era, are being dealt with...

Similarly, G. Robertson (1993: 46), the president of Federated Farmers of New Zealand, highlighted the economic imperative of sustaining the clean and green image:

> It is a matter of enormous concern to the farmers of New Zealand that the article’s assertions and their subsequent wider publicity will not only cause many New Zealanders unnecessary worries for their safety, but could needlessly put in jeopardy vital New Zealand trade.

The publication of the Szabo article was a defining moment for how New Zealanders engaged with the chemical promise, and the reality that the wastes generated from decades of agrochemical use were having impacts. As Dew (1999: 54) notes, ‘the political and public responses [to hazardous wastes] only became vociferous when the clean and green image was threatened.’ The necessity of chemical use for an agricultural nation, so heralded from the 1940s to the 1980s, was changed irrevocably.

However, Dew has also argued that much of the focus on hazardous waste during the 1990s was limited, as it was characterised by a privileging of ‘concern for contamination of the environment over the contamination of the people’ (1999: 53). He uses the case of New Zealand sawmill workers who claim their health has been adversely affected by their regular contact with the dioxin-contaminated timber treatment chemical pentachlorophenol (PCP). Dew demonstrates that a contaminated environment threatened business and political interests that relied on the clean and green image, and thus a series of responses to remedy the problem was mobilised. However, a ‘cleaning up of the people’ (Dew 1999: 54) was not necessary or even rendered visible, because human health did not have similar cultural and economic resonance as the clean and green myth.

The period from the late 1970s to the 1990s witnessed a fundamental change in the way agrochemicals and their effects were understood in New Zealand. The role of the IWD plant in producing dioxin-contaminated wastes, and the inability to properly contain these wastes, would highlight many issues for New Plymouth that had been silenced for the previous three decades. The next section discusses how the dioxin contamination of humans became visible in New Plymouth and how the changing character of science has both enabled and constrained the resolution of dioxin injustices.

Contemporary dioxin grievances and the limitations of science

On September 28, 2005, the New Zealand Ministry of Health announced at a meeting in New Plymouth that Paritutu residents had been exposed to higher dioxin levels than other New Zealanders and that this exposure might raise their risk of cancer up to 10%

above the national average. The MOH also noted that that these ‘observed elevations are, in all probability, mainly due to inhalation exposures from aerial emissions originating from the IWD plant during the years of 2,4,5-T production (1962–1987)’ (Fowles et al. 2005: iii). Andrew Gibbs, a local activist who had been campaigning for such recognition of the health effects of dioxins since 1999, noted that the MOH statement ‘overturned 30 years of denials, cover-ups and lies’. The connection between IWD’s manufacture of 2,4,5-T and ill health amongst Paritutu residents, silenced in the 1970s and discounted during the 1980s and 90s, was seemingly validated, resulting in a loud chorus of calls for compensation, justice and health support.

This historic change can be conceptualised as an example of a local environmental injustice addressed through similarly situated grassroots activism. In the late 1990s, several groups, including the Dioxin Investigation Action Group, the Dioxin Investigation Network and the Dioxin Legal Action Group, were formed in New Plymouth. Through media announcements and letter writing campaigns, these groups were able to nationally raise the profile of local dioxin issues, which resulted in the completion of several major reports between 2001 and 2006 on the effects of dioxins on the New Plymouth environment (Lucy & Proffitt 2002) and on the residents of Paritutu (Fowles et al. 2005; MOH 2006; O’Connor 2001, 2002; Read & Wright 2005). These led to the recognition that those living in Paritutu had been exposed to higher than normal dioxin levels.

To more fully understand what has happened in New Plymouth, the power/knowledge relationships between science, dioxins and society, and how much they have changed over the last 15–20 years need to be explored. The ability of the MOH to reach their

September, 2006 conclusion has been facilitated by several changes related to the role of science in the dioxin controversy.

First has been an increasing body of literature, and legislative action by numerous governing bodies, that have defined dioxins as a health risk. Citing long-term studies of occupational exposure in chemical plant workers, in 1997 by the International Agency for Research on Cancer (IARC), and in 1999 by the US National Toxicology Program, classified dioxin as a human carcinogen (MOH 2007). In addition, some approaches to chemical governance have replaced what Jacques (1992: 40) terms the 'beyond all reasonable doubt' approach to risk assessment, with one that seeks to judge the health effects of chemicals more within a 'balance of probabilities' paradigm. This is reflected in the stance taken by the US Institute of Medicine (IOM). The 1991 Agent Orange Act in the US required the IOM to review evidence of the health effects of dioxins. In assessing this evidence, the IOM (1994, 1996, 1999, 2001, 2003, 2005, 2007) has employed four categories in classifying illnesses as caused by dioxin exposure (Table 8.1). The US Veterans Affairs Department now accepts illnesses from the first two categories as being caused by Agent Orange exposure, and is often cited as an example of a progressive government policy, because it acknowledges the uncertainty inherent in 'real world' exposures of human to chemicals (Chapter 6).

While not as forthright as the IOM, the New Zealand MOH has adopted a position on dioxins and human health that is in stark contrast to its stance of the late 1980s: that dioxins cause only minimal human health issues in instances of high-dose exposure. Instead, the MOH (2007: 4) currently accepts there is difficulty in being able to adequately 'know', in a strict scientific sense, what dioxin does in the body:

> Whether adverse effects occur or not depends on what biological responses follow [exposure to dioxins]. These responses differ among and within species, and among tissues in individual species. Because of the potential diversity of biological responses to dioxins in the body it is currently not possible to state how, or at what levels, exposed individuals will respond. How much dioxin the person is exposed to and for how long is important as well as individual susceptibility. Many studies have looked at how dioxins can affect health and much is still not completely understood. Dioxins can affect the growth and development of cells in ways that have the potential to result in a broad range of adverse effects.

Thus, the 'invisible range of uncertainties' (Wynne 1992: 115), often ignored in the past, is now at least acknowledged, even if it does not necessarily guide government policy or compensation efforts.

A second significant change in dioxin science has been that a much clearer picture of population-level dynamics of dioxin exposure has emerged, which allows more accurate epidemiological modeling. Dioxin levels are now able to be measured accurately in human blood. Using what is known as 'blood serum testing', the approximately $2500 test examines up to 200 millilitres of blood to determine present, and often historical, levels of dioxins in humans, based on a 7–11 year half -life of the chemical. Many populations that suffered high dioxin exposures, such as residents living near the Sveso chemical accident (Chapter 7), and in certain parts of Vietnam, have had their blood serum levels assessed. In addition, people from both sexes with 'normal' dioxin exposures, from a wide range of ethnicities and age classes have been measured internationally (Sturgeon et al. 1998; Waliszewski et al. 1999; Liem et al. 2000). These data have been correlated with similar work on dioxin soil levels, thus allowing a relatively accurate method of understanding historical exposures.

New Zealand has been an international leader in utilising this science. Arguably, as part of the reaction to the Szabo article in 1993, the New Zealand Ministry for the Environment in 1995 initiated the Organochlorines Programme, a ‘whole of government’ strategy that has sought to better understand and manage dioxins. As a result, a series of studies was conducted that has, amongst other things, comprehensively assessed the level of dioxins and other organochlorine chemicals such as PCB’s in New Zealand’s food chain (Buckland et al. 1998), in its air, land and water (Buckland et al. 2000), in breast milk (Bates 1990) and in the general population (Buckland 2001; Smith & Lopipero 2001), and created a plan for reducing overall emissions and human exposures (MFE 1997; Smith & Lopipero 2001). These studies have allowed a relatively robust picture of dioxin levels in New Zealanders and of their geographic distribution. Thus, Fowles et al. (2005) were able to determine that the average TCDD level of the 52 past and present New Plymouth residents studied was 6.5 picograms per gram of fat (pg/g lipid), while the expected national average for a group of similar age and sex was 1.7 pg/g lipid.

These changes in the ability of science to understand dioxins have occurred during a period when the relationship between society and science is arguably being redefined. In her study of the use of science in environmental conflicts, Ozawa (2005: 334) notes that increasingly science is called upon to act as a ‘tool of facilitation’ in understanding and resolving disputes, particularly those involving chemical exposures in humans. How studies will be conducted, by whom, and towards what ends, are increasingly worked out through negotiations between groups involved with a dispute and those responsible for governing. Irwin (1995) has termed such engagement ‘citizen science’, while Corburn (2005: 218) calls it ‘street science’. This supposed co-production of knowledge between lay citizens and professionals has the potential to reduce mistrust in science, empower communities, and contribute to a constructive resolution, rather than to perpetuate the controversy through a polarisation of the lay and expert. During the conduct of the 2001–2006 MOH studies in New Plymouth, this facilitative role of science was evident in the extensive consultation that occurred, in the form of community meetings, informed agenda setting, approval of sampling methodologies and preliminary discussion of results.

The ability of science to better understand the extent of human-dioxin exposure while acknowledging the uncertainty in interpreting these results, along with the use of facilitative science, should be regarded as a positive step in the long-standing dioxin controversy. However, next it is argued that using only science-based approaches to resolve and reconcile dioxin injustices is insufficient, because of the socio-historic nature of the issue.

The limitations of science in resolving socio-historic injustices

As part of the eventual blood-serum testing of New Plymouth residents, the primary central government tool of the 2001–2006 period, the MOH contracted the Institute of Environmental Science and Research (ESR) to begin designing a study. Before the research methodology was finalised, a period of local consultation was undertaken to 'ensure that the plan reflect[ed] the needs and concerns of the affected residents and other key stakeholders' (Baker et al. 2003: 1). During these meetings, some residents argued that addressing only physical aspects of illness, and not the historical roots of the production and dissemination of dioxins, was insufficient. The ESR report summarised these concerns under an appendix entitled 'Concerns articulated, but largely historical and difficult to address through this study'. Included is this list are '(a) Distrust of government, science and industry, (b) Allegations of conflict of interest in key stakeholders, (c) Government support of 2,4,5-T production...[and] (f) Disputed facts relating to historical events' (Baker et al. 2003: 29). The MOH studies of 2001–2006, while acknowledging that dioxin exposure in humans above the normal level did occur in New Plymouth, have been unable to address many of the above concerns. This limitation is perhaps most evident in the case of New Plymouth birth defects purportedly caused by dioxin exposure.

While birth defects were a key part of the national discourse about dioxins during the 1970s (Chapter 7), their occurrence around the IWD plant in New Plymouth never really garnered much public attention. However, in April 2002, *Investigate,* a New Zealand current affairs magazine published an article entitled 'Toxic waste', with a follow-up article in May 2002. Both contained explicit images of New Plymouth birth defects from the late 1960s (Figure 15) and claimed that dioxin emissions from IWD were responsible. The pictures had been collected by Hyacinth Henderson, a Charge Nurse at the Westown Maternity hospital, then the largest birthing hospital in the wider Taranaki region and the only one in New Plymouth.

TOXIC WASTE:

is this the result of dioxin poisoning in New Zealand? HAMISH CARNACHAN investigates the terrible legacy the Government claims to know nothing about

Picture this: an early 1970's hospital ward in provincial boomtown New Plymouth, late afternoon sun streaming through the casement windows and catching little dust eddies in the air, making them sparkle. Nurses in crisply-starched white uniforms and caps march equally crisply along corridors, while somewhere nearby a newborn baby mews for its mother.

Yet to one woman walking the wards that day, something was inexplicably wrong. It just did not seem right. Why was this happening? As she patrolled the sterile hospital corridors, her eyes focusing on the rows of cots cradling helpless little newborns and, in particular, the infant wailing for a mother who would never come, the same questions ran through her mind over and over again. Why were there so many of these babies in the maternity ward, one in every 30 births, with gross disfigurements?

This was supposed to be one of the happier places in the hospital and the birth of a child was supposed to be one of the happiest days of the parents' lives. But it broke the senior health worker's heart to see parents walking away from these wretched little children. What was causing these defects so disturbing that even the children's parents were rejecting their very own flesh and blood?

In her 29 years of obstetric experience she had never seen anything like it. Was it the atomic bombs they were testing in the Pacific? Perhaps it was the weed spray the council was using in the streets or the farmers using on their land? None of the doctors seemed to have any answers but they were well aware that something out of the ordinary was causing an unprecedented rise in the number of congenital birth defects in the area.

The senior health worker was desperate to find the answers to put an end to the suffering and heartache.

28. INVESTIGATE April 2002

Figure 15 April 2002 Investigate article that claims a connection between 1960s dioxin emissions and birth defects. The article includes explicit pictures of birth defects taken at Westown Maternity Hospital, New Plymouth (*Source* Carnachan 2002: 28)

In a range of media pieces published since the *Investigate* articles, Henderson has stated that in 1965 she noticed a sudden increase in the number and severity of birth defects at the hospital. She contacted the DOH to alert them to the increase, and was told that 'the figures for all districts have now been examined and records for 1965 show no marked increase in these types of deformities [central nervous system]' (DOH 1966: 1). Henderson remained concerned, and decided that at least the deformities should be recorded for teaching purposes. Thus, she enlisted the hospital photographer to take detailed images of all deformities between 1965 and 1970, and she also recorded the incidences and types of birth defects in her own diary. When she transferred from Westown to an Otago hospital in 1971, the head doctor in New Plymouth gave her an album containing the pictures. No available DOH or TDHB records make any reference to the photographic collection, or the incidences of birth defects during the mid–late 1960s.

In 2001, spurred on by the increasing media coverage of dioxin issues in New Plymouth, Henderson contacted Patrick O'Connor, the TDHB Medical Officer of Health and told him the stories about birth defects that had lain dormant for over 30 years. When the *Investigate* articles came out, O'Connor was in the process of examining Henderson's claims. His report 'Neural Tube Defects at Westown Maternity Hospital, 1965–1972' was released in August 2002. It concluded that 'There are many factors involved in neural tube epidemiology, such as diet, genetic background, previous reproductive history, and postulated environmental factors. It is not possible from present data to link [past] neural tube defects at Westown Maternity Hospital...to any particular cause' (O'Connor 2002: 2).

The publication of the O'Connor study and the *Investigate* article resulted in past and present New Plymouth residents submitting numerous written stories to the Dioxin Investigation Network and media outlets about their birth defect experiences. These reports and stories have highlighted the role of Agent Orange production (Chapter 5) and the possible impact this had in New Plymouth. The beginning of Henderson's observation of elevated birth defects in New Plymouth during 1965 occurred at the same time that the production of military defoliants for US use in Vietnam began to alter the global TCP market (Chapter 5). It is likely that this increased demand led to the production of exponentially more dioxins in TCP, which eventually cross-contaminated 2,4,5-T production. Corroborating this, the recent MOH blood serum study (Fowles et al. 2005) has demonstrated that the period 1965–1970 was the period of highest fugitive dioxin emissions from the IWD plant. Thus, it has been speculated that the purported increase in birth defects during the late 1960s was a result of high dioxin levels.

However, as with O'Connor's study, a lack of sufficient information precludes even a partial understanding of the extent of past dioxin emissions and their potential role in causing birth defects because determining causative factors in birth defect epidemiology is notoriously difficult (Chapter 7).

Conclusions

In one sense, the case of Paritutu has been a quintessential example of an environmental (in)justice issue. Residents living in the vicinity of the IWD plant have made a case that ill health exists and that they are the victims of an environmental inequity. Yet Paritutu is also a case of how environmental injustices cannot be conceptualised as being fixed in time or space. The 30 years between the first debates around dioxins and the recognition that human health was affected near the production of 2,4,5-T, demonstrate how New Plymouth was silenced by the operating of discourses at other scale, while also contributing to a recognition of national-level waste issues. Kurtz (2003: 888) refers to this as the 'spatial ambiguity' inherent in both the characterisation and resolution of environmental injustices. That is, there is an inherent disjuncture between the scale at which a problem is generated and the scales at which it is experienced. Thus it is important when defining a problem as only local that the myriad other relationships that caused the problem in the first place are characterised and discussed (Kurtz 2003: 890).

Chapter 9: Conclusions

This thesis has sought to look into the past, in order to help better understand dioxin controversies in the present in New Zealand, in particular the claims of environmental (in)justice emanating from New Plymouth. This concluding chapter is in three parts. The first briefly outlines the theoretical approach utilised in the thesis and reiterates the importance of focusing on the 1970s period. The second section discusses how the main findings have answered the research questions. The third section outlines how this thesis has added to our knowledge about environmental (in)justices and poststructural understandings of power/knowledge and scale.

Chapter 2 argued that environmental injustices need to be conceptualised as more than just the local manifestation of structural inequities that result in disproportionate exposures to toxic pollution. Instead, such injustices represent a complex and tangled web of socio-historic relationships enacted across and through numerous spaces (Pellow 2002; Pellow & Brulle 2005; Szasz & Mueser 1997). Environmental justice research has grown in scope and increasingly a broad range of theoretical approaches are being applied to issues of toxics and society. However, the application of poststructural social theory, particularly as it has been developed by critical human geographers, to environmental justice scholarship has been limited.

Thus, this thesis sought to utilise a theoretical approach grounded in poststructural understandings of spatiality, power, knowledge and discourse to interpret these past–present spaces. Space and scale have been conceptualized not as fixed and inert containers within which social relations occur. Instead they are the outcome of spatially situated interactions between a range of human and non-human actors. This perspective, informed by actor-network theory, recognizes that the outcomes of these relational encounters are temporary accomplishments that endure or diffuse based on the strength of their connections with other situated spaces.

While dioxins have existed as a chemical contaminant since at least the 1930s, this thesis has sought to focus primarily on the early-1970s period to help understand the present. It has done this for several reasons. First, the existence of dioxins became public knowledge only in late 1969, and the early articulations of how they should be managed have not previously been researched extensively. Second, the early-1970s period was a tumultuous time in many Western countries, as the effects of the unprecedented scientific and technological growth of the previous three decades became pressing social concerns. The effects of chemicals on humans was one of these concerns and the industry and regulatory response during the 1970s was what became the governance strategy of risk assessment. During the early 1970s, ‘risk assessment’ was not yet a widely used term; however, many of the rationalities and discursive practices that would be encapsulated by the term were in a formative period of their history.

Research questions and findings

What are the discourses of human health, science and chemicals that have formed the contested narratives of risk assessment and dioxins?

Chapter 4 argued that one of the main discourses during the 1940s–1980s period that underpinned the conditions of possibility (O'Farrell 2005) of the dioxin controversy was the 'chemical promise'. This discourse was part of the unique relationships between academia, industry and government brought on by the Second World War, which can be termed 'Big Science' (Adam et al. 2000). This intensive capital and scientific transformation was marked by unprecedented changes in the scale and complexity of technological innovation, which were particularly evident in the growth of the chemical industry. One of the products of these relationships was agrochemicals, which promised to increase yields, reduce labor, and raise profits. The discourse of chemical promise was composed of utopian constructions of science as a source and means of unlimited potential to improve society. The phenoxy herbicides, particularly 2,4-D and 2,4,5-T epitomised this promise, especially in New Zealand. The ability of phenoxies to be selective, killing only certain weeds while letting beneficial pasture grasses survive, was revolutionary for an economy and society reliant on agriculture. The 'golden years' (1940s–1960s) of the chemical promise fundamentally altered the productive capacity and methods of agriculture, and thus entrenched their use in New Zealand, as well as internationally.

Chapter 5 detailed how dioxins were unavoidable contaminants created during the production of TCP, a precursor ingredient in 2,4,5-T. During the 1940s–1960s period, dioxins were one of many kinds of contaminants that represented a hidden and silenced part of the chemical promise. Within the chemical industry, contaminants such as dioxins were initially made real only if they interfered with production processes or with the health of workers or the public. And during the 1940s to the 1960s, acute (short-term) effects on worker health appear to have been the only way dioxins were conceptualised by industry. The specific manufacturing processes that resulted in low-dioxin TCP did not become industry standard practice in part because knowledge about dioxins was initially not openly shared within the industry, but was commodified, with the resulting trade specifications only purchased by only some companies.

Dioxins became a public issue in late 1969, largely as a result of the US Bionetics study. Chapters 5 and 6 demonstrated that the acceptable dose discourse, publicly articulated in the wake of the Bionetics results, became a central plank of the chemical industry and government defense of continued 2,4,5-T use. The concept of an acceptable dose was, and still is, a core idea of toxicology, which states that every substance has a harmful dose, and conversely all substances have a safe, or acceptable dose. The chemical industry, led primarily by Dow Chemicals USA, constructed this discourse around the notion that the presence of dioxin in the low parts per million (ppm) range was a safe level in 2,4,5-T. This approach normalised the production of certain levels of dioxins. While a range of uncertainties existed about how dioxins behaved in the environment and the human body, the discourse of acceptable dose constructed them as manageable through the use toxicological and epidemiological methodologies and their grounding in rationalistic thinking and quantification.

During the early 1970s, a range of individuals and groups began to criticise the adequacy and role of science in being able to contain the effects of rapid technological change occurring in many Western countries (Chapters 5–7). Anti-chemical sentiment, growing since the 1960s, presented a series of critiques that today are often encapsulated by the term ‘the precautionary principle’. In the case of dioxins, this oppositional discourse was composed of arguments that questioned the ability of toxicology and epidemiology to adequately comprehend the uncertainty inherent in human–chemical interactions.

How were these discourses constituted, sustained and made hegemonic by industry and government while simultaneously being challenged by social movements? ***AND*** *What role does scale have in the formation, legitimating and challenging of such discourses?*

These questions are best answered together because, as this thesis has demonstrated, scale has been impossible to disentangle from the processes of discursive formation and legitimation. Categories of scale such as national and local are not fixed containers within which actors and events coalesce. Instead, scale is a social construction that encourages thinking about space as simultaneously socially produced and socially producing (Herod 1991). As the following summary of the main findings discusses, it is also important to think about scale in relation to power. Chapters 4–8 have demonstrated that power is not hierarchal, nor is it being imposed from afar in a linear and intact fashion by fixed actors. Instead, power is generated and made real through social relations in, across and between different spaces (McHoul & Grace 1997; Sharp et al. 2000)

The chemical promise was sustained both by symbolic and material layers, as Chapter 4 has shown. Materially, the chemical promise to transform agriculture was supported by new technologies such as spray pumps and aerial application, which allowed the widespread use of 2,4,5-T, and by State subsidies that facilitated the continued use of agrochemicals. The chemical industry also purveyed utopian ideas about agrochemicals through advertising that situated science and technology as the means by which social and material progress would be achieved.

One key set of processes at work in constructing the chemical promise and the 1970s controversies were the flows and influence of overseas arguments, materials, technologies and actors in constituting dioxin discourses in New Zealand. The country was reliant on these flows, but it also changed and applied them in unique ways. Ivon Watkins-Dow (IWD), while physically situated in New Plymouth, was a subsidiary of several large overseas chemical companies and was dependent on these connections for raw materials and to lesser extent, market innovations and product branding (Chapter 4). Dioxins first attracted regulatory attention in the US in 1970 when testimony at several prominent Senate hearings was influential in establishing the acceptable dose discourse (Chapter 5). In New Zealand it is clear from these early debates, and for most of the 1970s, that the Agricultural Chemicals Board (ACB) and the Department of Health (DOH) were primarily reactive to how the US government approached the emerging knowledge, rather than proactive in deciding their own course (Chapter 6). In the case of assessing the levels of dioxins in 2,4,5-T, New Zealand agencies such as the Department of Scientific and Industrial Research had to rely for several years on Dow technology and understanding about dioxin analysis (Chapter 6).

Similarly intermeshed in these flows between and amongst scales was a range of other practices that affected the construction of dioxin discourses. Some of these acted to minimise or exclude certain perspectives, while others insulated the dominant understandings of dioxins from critique. One of the most common practices was repetition through commentary. Chapter 7 showed this by describing how the ACB and DOH reacted to accusations of birth defects by two rural physicians by reiterating and expanding on the principles of toxicology and epidemiology. The argument that was voiced most often, acceptable dose, even if critiqued, tended to act as the reference point for the next set of ideas in future discourse.

The ability to repeat and comment on certain ideas was also related to professional standing and disciplinary orientation. The social production of discourse involves a delimiting of speaking subjects, where voices are able to legitimately contribute to the formation of a discourse only if they meet certain requirements (McKnay 1994: 87). In the case of dioxins, only certain groups and institutions were constructed as having access and command of key knowledges (Chapters 5–7). Much of this was expertise created by a select segment of the chemical industry. Dow Chemicals USA was a leader in analytical chemistry and had been able to 'see' and understand dioxins a decade before government scientists. In addition, the ACB, the DOH and IWD acted as a coherent disciplinary group that defined and defended dioxins, not necessarily by overt collusion, but instead through an entrenched adherence to the techniques and language of toxicology and epidemiology (Chapter 7).

This thesis has demonstrated that Dow Chemicals USA was, using a Latourian term, a 'centre of calculation.' The notion that an acceptable dose of dioxin existed, and could be managed in the wider environment had been formulated in toxicology laboratories, particularly at those of Dow Chemical USA, then the world leader in analytical chemistry. The acceptable dose allowed laboratory conditions to be transported, and applied to, dioxin's interactions with society more generally. At each local site where the acceptable dose was debated and applied, the US Senate hearings, the New Zealand Department of Health, the popular media, the analytical testing of DSIR and the production processes of New Plymouth, the idea that dioxins could be controlled was further strengthened through the enrolment of these locales. The successful local application of the acceptable dose tenet strengthened the position of Dow Chemicals USA and facilitated its claims, and subsequently those of national governments, that exposures to known quantities of dioxins would not cause human health concerns. This demonstrates that the 'power' of science lay not with the abilities of scientists themselves to understand dioxins, but instead in the relationships that are enacted spatially between various actors and entities.

While those critiquing the dominant acceptable dose approach represented a range of professional, scientific and lay perspectives, they were often universalised as non-rational and emotive (Chapter 7). Wynne (2001: 452) characterises this as the belief that 'expert knowledge is grounded in reality, whereas lay knowledge and attitudes are politically real but intellectually unreal' (Wynne 2001: 452). Such constructions undermined the arguments of these alternative perspectives, despite many of their precautionary arguments being based in scientific logic and thought.

The critiques of risk assessment that were levelled against dioxins during the 1970s were also undermined by the ability of the chemical industry and governments to more effectively employ 'positive scientific rhetoric' (Sismondo 2004: 142). Latour and Woolgar (1986) suggest that scientific facts are marked by a lack of modality where the fact is not even presented as such but instead is taken for granted in the process of establishing other facts. The acceptable dose was established as a fact by processes of repetition, but also by a wide range of allies that were enrolled in disseminating and authorizing the ideas and technologies encapsulated in acceptable dose. This stacking of allies not only enhanced the position of the scientific fact, but it also served to isolate counter arguments that were simultaneously trying to emerge (Latour 1987). While physicians and scientists were two of the many voices critiquing risk assessment, they tended to act in an isolated and disparate fashion when compared to the dominant voices of industry and government.

A final aspect of the discursive construction of dioxins are the numerous silences that have and continue to influence our understanding about the chemical. Chapter 5 argued that the production of dioxin-contaminated defoliants for military use, most famously Agent Orange, has contributed to a very limited understanding internationally and in New Zealand of the 1965–1970 period: while other periods, such as the 1970s and 1980s, witnessed much higher production volumes of 2,4,5-T, the quantities of dioxin during these years was exponentially lower than for the brief 1965–1970 period when pressure to meet military use resulted in ‘dirty’ manufacturing processes. The exact quantities of dioxins produced, how the wastes were managed, what companies had high dioxin levels in their products and the details of how the chemical industry managed the issue without informing governments, are all unanswered questions about this period.

While the 1960’s silences around military defoliant use were arguably intentional, silences were also created through other processes. Chapter 8 argued that the regulated 1 ppm and 0.1 ppm levels did not actually reduce the creation of dioxins; they just concentrated the chemical locally at its point of manufacture. The use of solvents to remove dioxins from the 2,4,5-T destined for market resulted in a large volume of contaminated liquid and solid wastes. As with contaminants during the previous decade, wastes from chemical manufacturing were not part of the public discourse about dioxins during the 1970s. In New Plymouth, the resulting wastes were incinerated at IWD and buried in various locations around the region. This local contamination was also silenced because national attention was focused on birth defects issues that were becoming the dominant construction of dioxins and human health concerns (Chapter 7).

These silences of the past are also part of contemporary arguments about injustice in New Plymouth and amongst other dioxin affected groups, such as sawmill workers, ex-IWD employees and Vietnam veterans. Chapter 8 argued that several important changes have taken place that have allowed a move towards resolving these injustices. Unlike the 1970s, public health officials now accept that uncertainty exists in understanding human–chemical interactions and range of studies have demonstrated that dioxin promotes cancer and disrupt the endocrine system in numerous, although not well understood ways. Further, advances in blood serum analysis have allowed MOH officials to demonstrate that people who lived near the IWD plant, particularly during the 1960s and 70s, were exposed to higher levels of dioxins than other New Zealanders. While such recognition is positive, it is incomplete. The continued silences of the past impede closure for many and they demonstrate the complex historical basis of many environmental (in)justices.

Conclusions

Poststructural understandings of power/knowledge, discourse and scale have not been part of the mainstream of environmental justice scholarship, which has traditionally conceptualised power in structural terms and inequities as primarily local. Understanding scale as a social construction challenges this central motif of environmental justice. Herod (1997) notes that recognising that scales are materially constrained by actors and that the creation, ordering and reconfiguring of scales is inherently political, necessitates a consideration of how actors (human and non-human) create geographic scales through multiple relationships and activities. Like Kurtz (2003), this thesis highlights how such an approach to environmental justice thus allows a movement away from the simplistic understandings of NIMBYism and corporate power towards types of analysis that reveal the multiple, historical, and situated character of environmental injustices.

This thesis has demonstrated that such thinking about power as non-hierarchal, diffuse and created through calculative rationalities and knowledge-making practices can be a useful way to understand the injustices created in part by chemicals such as dioxins. The story of 2,4,5-T production in New Plymouth has demonstrated that 'local' environmental injustices are at any one time a reflection of numerous socio-historic variables, multiple stakeholders and 'shifting interests and allegiances, rather than simpl[e]...perpetrator-victim scenarios' (Pellow 2000: 588). While Pellow and Brulle (2005) and Szasz and Mueser (1997) did not suggest a poststructural approach when they called for environmental (in)justice research to become more historical and scalar, this thesis argues that such understandings of power/knowledge should be considered in future research.

A central focus of environmental justice research has been on highlighting the unequal spatial distribution of environmental risks. Subsequently, much theorizing has sought to outline how a more equitable distribution of such risks is possible within an unequal society. However, these approaches often fail to address the creation of such risks in the first place and inadequately interrogate the processes and rationalities that precede distribution. This thesis has demonstrated that a poststructural approach, particularly to understanding the knowledge-making practices inherent in risk assessment, can be useful in critiquing how decisions about toxics are made. It is important to note that it does not follow that distributional approaches should be disavowed. Instead, environmental justice research needs to continue to be open to a range of theories of what constitutes (in)justices, equity and fairness (Walker & Bulkeley 2006).

The findings of this thesis also suggest that a common criticism of poststructural understandings of power, that is that power is everywhere thus it is nowhere, should be tempered by a recognition that network conceptions of power still provide a useful basis for political action and the resolution of historical grievances. Environmental justice research and activism has in many ways been hindered by the dominant constructions of scale insofar as a tension has been apparent between the scales at which injustices have occurred and been experienced (typically local), and with the scales at which they have been resolved politically (often national) (Towers 2000). This approach has led to the narrow resolution of some environmental justice issues such as NIMBYism through relocating offending industries or the passing of national regulations. This model continues to perpetuate a simplistic view of society where powerful entities like the chemical industry negatively affect local communities. However, a network approach allows a more complete picture to emerge, where the practices and rationalities employed historically to manage chemicals are revealed. Understanding and being able to describe these spatialised sites of interaction where practices are made and remade may facilitate more effective responses and critiques to the dominance of risk assessment as a way of governing chemicals.

The case of 2,4,5-T in New Zealand also highlights the need to pay attention to how 'non-discursive relations form the conditions of possibility [for the emergence] of certain discourse' (McKnay 1994: 87). For instance, the importance of 2,4,5-T to the New Zealand economy and the ability of the chemical industry to restrict the flow of information about dioxins have been vital to why certain discourses about dioxins have been dominant, while others have been minimised. While power may be conceptualised as *everywhere* in poststructural thinking, it should be recognised that it is *uneven*, and that certain actors may during certain periods have a disproportional influence on discursive constructions.

Finally, this thesis has also demonstrated that difficulties exist in being able to fully represent how relational encounters can be understood because certain sources of empirical material are more readily available than others. In the case of dioxins in New Zealand, the new and critical narrative about the emergence of risk assessment presented here could be carried out because of the availability of archival materials and by using the Official Information Act. While, these records allowed previously silenced accounts of how government and industry promoted science-based approaches to understanding human health to be brought together, several aspects of these interactions are more difficult to interpret.

As noted in Chapter 3, many of the chemical industry correspondences with the New Zealand government are not contained in the archival files, nor was the current company, DowAgroSciences Ltd., willing to provide any materials or statements for this research. In addition, it was difficult to investigate and thoroughly contextualise the role of activists, non-governmental organizations and other voices who critiqued the emergence of dioxin risk assessment. This was in part because such criticisms were only beginning to become public in mediums, like media and government correspondences, that survive to be historically reinterpreted later. Addressing how to more adequately incorporate such voices in historical cases should be a focus of future poststructural research in environmental justice.

This thesis began by suggesting that the development of industrial chemistry, particularly since the Second World War, has created a distinct chemical politics. To understand such a politics, we should 'follow the molecule' to see how it affects bodies, environments, communities and nations. The previous chapters have demonstrated that the effects of this movement, both on politics and people, have been substantial, and they endure. In 1985, Major John Moller (Ret.) a New Zealand veteran of the Vietnam war and still a loud voice arguing for recognition of the effects of exposure to Agent Orange and military chemicals during the war stated (Moller 1985) that, 'As the only country in the world still manufacturing and exporting 245T we are either potentially arrogant or stupid. It would be a pity if history judged us as being both.' This thesis has demonstrated that the dioxin controversy has, and in many ways continues to be, typified by a reverence to rationalistic thinking. The emergence of risk assessment as a governance strategy in the early 1970s and its uncritical reliance on toxicology and epidemiology, despite numerous uncertainties about how well these sciences could understand dioxins, was ‘potentially arrogant.’ Despite being romanticised as ‘under control’, dioxins were not contained or understood sufficiently by science to prevent their movement outside of factories and into our bodies, environments, and wider communities. Our stupidity, in Moller’s analysis, lies perhaps in our overestimation of the ability of rationalistic thinking to sufficiently understand the complexities inherent in human–chemical–society interactions.

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Notes:
In some cases the author and/or receiver of a correspondence is unknown because they were not listed, or because their name was redacted because of Official Information Act restrictions. In such cases, only the organisation and/or position/title is displayed. See Appendix 1 for a complete list of files accessed at National Archives Wellington and Appendix 2 for a complete list of files accessed at the Agricultural Chemicals and Veterinary Medicines Group of the New Zealand Food Safety Authority, Wellington.

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WILKES, O. to DOH, 24 Jan. 1973b, activist collection.

Appendix 1: All files accessed and searched at National Archives, Wellington, New Zealand

Note: (–) indicates that this information is not available for the file series

Agency	Accession	Box #	File #	Alt. #	Date	Title
1	–	–	1/18/10	33189	1962–67	Nursing Services: returns public Health NP
AADJ 632	W6783	39	63/3	–	1974–86	Env. Chemistry, Chem. Agents Ag. Chems
AAFB	W4914	75	156/11/48/1	46786	73–77	Poisons, Subs., 2, 4, 5–T
AAFB	W3463	56	156/11/48/1	47080	5/73–3/77	Poisons, Subs., 2, 4, 5–T
AAFB	W4914	99	156/11/48/1	47146	5/77–6/77	Poisons, Subs., 2, 4, 5–T
AAFB	W4914	159	156/11/48/1	47934	4/77–3/78	Poisons, Subs., 2, 4, 5–T
AAFB	W4914	253	156/11/48/1	49070	2/78–4/79	Poisons, Subs., 2, 4, 5–T
AAFB	W3463	13	156/11/105	36652	65–70	Poison, substances, triazines
AAFB 632	W3563	10	32/272	35870	1953–70	Sewage and Drainage: New Plymouth
AAFB 632	W3463	79	156/1/2	47555	1956–76	Poisons Act, Overseas Legislation
AAFB 632	W3464	224	156/13/1	28654	61–65	Poisons
AAFB 632	W3463	75	156/14/3	–	73	Poisons, ACB Horticultural Crops Committ.
AAFB 632	W3463	76	156/14/4	–	73	Poisons: Ag. Chem. Board Executive Com. Meetings Agenda
AAFB 632	W3463	76	156/14/4	47516	73	Poisons: Ag. Chem. Board Executive Com.
AAFB 632	W3463	76	156/14/7	–	66–75	Poisons, ACB Insecticides on Pastures, Fodder Crops Committee
AAFB 632	W3463	115	156/2	48166	75–78	–
ABLQ	W4147	111	247/4	–	1969–73	Agricultural Chemicals Board, Pasture Committee
ABLQ	W4147	111	247/4	–	1973–77	Agricultural Chemicals Board, Pasture Committee
ABLQ	W4147	111	247/5	–	1969–72	Agricultural Chemicals Board, Horticulture Committee
ABLQ	W4147	111	247/5	–	1972–74	Agricultural Chemicals Board, Horticulture Committee
ABLQ	W4147	111	247/5	–	1974	Agricultural Chemicals Board, Horticulture Committee
ABLQ	W4147	111	247/5	–	1974–76	Agricultural Chemicals Board, Horticulture Committee
ABLQ	W4147	111	247/5	–	1976–78	Agricultural Chemicals Board, Horticulture Committee

ABLQ	W4147	111	247/6	–	1969–71	Agricultural Chemicals Board, Specifications Committee
ABLQ	W4147	111	247/6	–	1971–73	Agricultural Chemicals Board, Specifications Committee
ABLQ	W4147	111	247/6	–	1974–76	Agricultural Chemicals Board, Specifications Committee
ABLQ	W4147	112	247/7	–	1969–76	Agricultural Chemicals Board, General
ABQU	W4452	960	156/11/146	78338	77–88	Hexachlorophene
ABQU 632	W4550	33	156	47961	1967–79	Poisons
ABQU 632	W4452	931	156/7/6	77839	1959–80	New Plymouth Health District
ABQU 632	W4550	33	156/11	46029	–	–
ABQU 632	W4550	33	156/11	50115	6/75–9/76	Poisons, Substances, General File
ABQU 632	W2788	–	156/11/48/1	39110	71–4/72	Poisons, Subs., 2, 4, 5–T
ABQU 632	W2788	–	156/11/48/1	40010	3/72–4/73	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	49667	11/78–4/79	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	49670	1/79–5/79	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	50017	5/79–9/79	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	50357	7/79–3/80	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	–	156/11/48/1	50461	2/80–3/80	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	359	156/11/48/1	50898	2/80–8/80	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4550	33	156/11/48/1	51247	6/80–12/80	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	53407	1/81–2/82	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	55162	2/82–6/83	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4415	358	156/11/48/1	57948	6/83–2/85	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	58439	85	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	58950	5/85	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	59593	85–86	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	60218	86	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	948	156/11/48/1	60786	1986	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	947	156/11/48/1	62438	86–87	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	949	156/11/48/1	77949	87–91	Poisons, Subs., 2, 4, 5–T
ABQU 632	W4452	–	156/11/48	30097	62–64	Poisons, Subs., Horm. Weedicides

ABQU 632	W4452	–	156/11/48	31026	64–66	Poisons, Subs., Horm. Weedicides
ABQU 632	W4452	–	156/11/48	32787	66–67	Poisons, Subs., Horm. Weedicides
ABQU 632	W4550	33	156/11/48	–	76–79	Poisons, Subs., Horm. Weedicides
ABQU 632	W4415	357	156/11/48	53116	6/79–81	Poisons, Subs., Horm. Weedicides
ABQU 632	W4415	357	156/11/48	56251	81–83	Poisons, Subs., Horm. Weedicides
ABQU 632	W4415	357	156/11/48	57601	84	Poisons, Subs., Horm. Weedicides
ABQU 632	W4452	947	156/11/48	59502	84–85	Poisons, Subs., Horm. Weedicides
ABQU 632	W4452	947	156/11/48	77948	85–92	Poisons, Subs., Horm. Weedicides
ABQU 632	W4452	949	156/11/48/2	50621	80–89	Poisons–substances–agent orange
ABQU 632	W4452	949	156/11/48/2	53306	2/82–6/81	Poisons–substances–agent orange
ABQU 632	W4452	949	156/11/48/2	55408	82–83	Poisons–substances–agent orange
ABQU 632	W4452	949	156/11/48/2	57716	83–84	Poisons–substances–agent orange
ABQU 632	W4452	950	156/11/48/2	77950	83–92	Poisons–substances–agent orange
ABQU 632	W4452	950	156/11/48/3	77951	80–90	Investigation of alleged congenital
ABQU 632	W4415	365	156/11/154	49767	63–78	Poisons, substances, pesticides, general
ABQU 632	W4415	365	156/11/154	55332	81–83	Poisons, substances, pesticides, general
ABQU 632	–	–	156/11/154	66687	89	Poisons, substances, pesticides, general
ABQU 632	–	–	156/11/154	68541	–	Poisons, substances, pesticides, general
ABQU 632	W4452	971	156/12/7/1	78312	62–86	Prescription Poisons: Foetal Deformities
ABQU 632	W4452	972	156/14/9	78296	71–91	Publicity Committee Meetings
ABQU 632	W4452	974	156/18/1	78289	61–90	Poisons Act 1960: The Ag and Hort Poisons Advisory Committee
ABQU 632	W4452	974	156/18/2	78227	75–80	Advisory Committee on Commercial and Household Agricultural
ABQU 632	W4452	974	156/18/2/1	78226	75–79	Advisory Committee on Commercial, Household, and Ag. Poisons:
ABQU 632	W4452	974	156/20	78225	81–90	–
ABQU 632	W4452	975	156/22	78231	72–92	Poisons: Consultant Toxicologist
ABQU 632	W4452	975	156/23	78230	74–81	Poisons: Possession of Poisons for Experiment
ABQU 632	W4452	975	156/25	78228	76–89	Hazardous Chemicals in Industry Committee
ABQU 632	W4452	975	156/25/1	78223	81–86	Industrial Chemicals Committee: Agenda
ABQU 632	W4452	975	156/25/2	78222	77–81	Industrial Chemicals Committee: Corresp.

ABQU 632	W4452	975	156/26	78221	77–87	Working Party on Scheme for Screening and Control of Toxic
ABQU 632	W4452	986	156/36/1	61120	6/86–8/26	Com. of Enq into the impact of NP residents health from Ag. Chem.
ABQU 632	W4452	986	156/36/1	61642	9/86–12/86	Com. of Enq into the impact of NP residents health from Ag. Chem.
ABQU 632	W4452	986	156/36/1	62346	12/86–5/87	Com. of Enq into the impact of NP residents health from Ag. Chem.
ABQU 632	W4452	986	156/36/1	78199	–	Com. of Enq into the impact of NP residents health from Ag. Chem.
ABQU 632	W4415	449	177/143/29	55928	1978–84	Sanitation, Haz. Wastes, Cen. Reg. Survey
ABQU 632	W4415	449	177/143/29	57369	1983–84	Sanitation, Haz. Wastes, Cen. Reg. Survey
ABQU 632	W4415	574	340/3/138	58076	62–76	Air Pollution, Works, IWD
ABQU 632	W4452	1488	340/3/138	–	85–86	Works, IWD, New Plymouth
ABQU 632	W4452	1489	340/3/138	59301	85	Works, IWD, New Plymouth
ABQU 632	W4452	1488	340/3/138	60745	86	Works, IWD, New Plymouth
ABQU 632	W4452	1489	340/3/138	62509	86–88	Works, IWD, New Plymouth
ABQU 632	W4452	1488	340/3/138	62510	3/86–7/87	Works, IWD, New Plymouth
ABQU 632	W4452	1492	340/3/264	–	61–79	McKechnie (NZ) New Plymouth
ABQU 632	W4452	1492	340/3/383	–	66–80	NZ Electrical Dept. New Plymouth
ABQU 632	W4415	573	340/1	56795	57–72	Air pollution, regulations
ABQU 632	–	–	340/3	31343	62–66	Air pollution, works, general file
ABQU 632	W4550	50	340/3/21	57127	58–75	Air pollution, works, offensive trades
ABQU 632	W4452	1495	340/3/740	–	73–87	New Plymouth Health District: General
ABQU 632	W4452	1505	340/52/1	–	71–90	Air pollution monitoring, New Plymouth
ABQU 632	–	–	340/7	30251	59–64	Air pollution, chemical inspector
ABQU 632	–	–	340/10	30181	59–64	Air pollution, miscellaneous enquires
ABWN 6095	W5021	550	22/260/9	–	1963–70	Hormone Weedkillers
ABWN 6095	W5021	551	22/260/9	–	1971–75	Hormone Weedkillers
ABWN 6095	W5021	551	22/260/9	–	1976–79	Hormone Weedkillers, Pesticides Bill
ABWN 6095	W5021	551	22/260/9	–	1979–82	Hormone Weedkillers, Pesticides Bill
ABWN 6095	W5021	551	22/260/9	–	1984–86	Hormone Weedkillers, Pesticides Bill
Ag 40	–	–	–	30004	49–67	Aerial Spraying of Crops
Ag 40	–	–	–	60313	63–65	Dangerous Sprays Pt. 3

Ag 40	–	–	–	60313a	61–65	Dangerous Sprays Civil Aviation Correspondence Pt. 2
Ag 40	–	–	–	60695	58–64	Insecticides– General
Ag 40	–	–	–	60978	57–64	Spray Damage to Crops, Claims and Generally
Ag 40	–	–	–	60978	65	Spray Damage to Crops, Claims and Generally
Ag 40	–	–	–	60978	65	Spray Damage to Crops, Claims and Generally
Ag 40	–	–	–	60978	66–68	Spray Damage to Crops, Claims and Generally
Ag 40	–	–	–	60982	62–65	Spraying Mixtures General
Ag 40	–	–	–	60984	62–68	Spraying Records Charts
Ag 40	–	–	–	60984	38–61	Spraying Records Charts
Ag 40	–	–	–	61155	62–65	Weed Con. Experiments/Trials
Ag 40	–	–	–	61384	61–62	Agricultural Chemicals Newsletter
Ag 40	–	–	–	61384	62–63	Agricultural Chemicals Newsletter
Ag 40	–	–	–	61384	63–65	Agricultural Chemicals Newsletter
Ag 40	–	–	–	61384	66–67	Agricultural Chemicals Newsletter
Ag 40	2921	–	–	60313	66–73	Dangerous Sprays
Ag 40	2921	–	–	60313A	67–77	Dangerous Sprays, Admin Corresp.
Ag 40	–	–	60978	–	57–64	Spray Damage to crops, claims and generally
Ag 40	–	–	60978	–	67–68	Spray Damage to crops, claims and generally
Ag 40	–	–	60978	–	68–69	Spray Damage to crops, claims and generally
Ag 40	–	–	60978	–	69–70	Spray Damage to crops, claims and generally
Ag 40	–	–	60978	–	61–64	Spray Damage to crops, claims and generally
Ag 40	–	–	30733	–	50–64	Ammonium 2,4–D & related
Ag 40	2921	–	60313	–	66–73	Dangerous Sprays
Ag 40	2921	–	60313A	–	66–73	Dangerous Sprays–Civil Aviation
Ag 40	2747	–	30319	–	61–69	IWD Ltd. New Plymouth
Ag 40	–	–	30212	–	69–73	Aerial Topdressing/ Ag Aviation General
Ag 40	–	–	30004	–	49–67	Aerial Spraying of crops
H	W2262	–	156/14/1	50169	78–79	Poisons: Agricultural Chem. Board Meeting
H	W2191	44	340	34350	63–69	Air Pollution, general part 1

H	W2191	44	340	38422	69–71	Air Pollution, general part 2
H	W2191	44	340	30111	57–64	Air Pollution, general
H1	–	–	53/74/3/8	32197	–	–
H 1	–	–	139/15/1	39692	70–71	Occupational Health, Agricultural Poisons
H 1	–	–	139/15/9	39696	66–71	Occupational Hlth, Aerial Spraying Poisons
H 1	–	13	156/3	–	68–69	Poisons, Labelling, General
H 1	W2676	3	156/11/48	34258	67–69	Poisons, Subs., Horm. Weedicides
H 1	W2676	41	156/11/48	36217	69–70	Poisons, Subs., Horm. Weedicides
H1	W2676	3	156/11/48	34258	67–69	Poisons, Subs., Horm. Weedicides
H1	W2676	41	156/11/48	36217	69–70	Poisons, Subs., Horm. Weedicides
H1	W2676	–	156/11/48	38537	8/70–9/71	Poisons, Subs., Horm. Weedicides
H1	W2676	–	156/11/48	41203	9/71–10/74	Poisons, Subs., Horm. Weedicides
H1	W2676	–	156/11/48	45840	74–76	Poisons, Subs., Horm. Weedicides
H1	W2676	–	156/11/48	49719	10/74–5/76	Poisons, Subs., Horm. Weedicides

Appendix 2 All files accessed and searched at the Agricultural Chemicals and Veterinary Medicines Group of the New Zealand Food Safety Authority

Note: (–) indicates that this information is not available for the file series

File no	Subject	Year opened	Notes	Box
PB2/1 Vol1	Agchem Board minutes	4/28/60	–	3
PB257	Agroxone MCPA	1/26/61	Registration File	1
261	Tartan MCPA	2/22/61	Registration File	1
PB259	mizer MCPA	2/22/61	Registration File	2
PB2/1 Vol2	Agchem Board minutes	11/28/63	–	3
Shell 46	Shell MCPA	2/7/64	Registration File	2
PB2/6 Vol1	Minutes of plant damage committe	5/5/64	–	3
PB3/1 Vol3	Agchem Board minutes	1/26/67	–	2
PB2/4/5	Agchem Board Correspondance	8/1/67	–	2
PB1510	Cropper'2,4,5-T	10/11/68	Registration File	1
PB13/1 Vol 1	2,4,5-T all correspondance relating to	10/31/69	–	1
241	Seveso Incident + australian notes	1/1/70	—	2
PB13/1 Vol2	2,4,5-T	8/1/71	Correspondance and Press	3
PB13/1 Vol3	2,4,5-T	4/1/72	Correspondance and Press	3
PB13/1 Vol4	2,4,5-T	11/1/72	Correspondance and Press	3
PB13/1 Vol 5	2,4,5-T	7/1/73	Correspondance and Press	3
PB2/1 Vol4	Agchem Board minutes	9/1/74	–	3
PB13/1 Vol 6	2,4,5-T	1/1/75	Correspondance and Press	1
–	2,4,5-T and human birth defects	6/1/77	–	3
PB13/1 Vol 7	2,4,5-T	4/25/79	DOW and press related material	1
PB13/1 Vol 8	2,4,5-T	4/26/79	Correspondance and Press	1
PB13/1 Vol 9	2,4,5-T	9/1/79	Correspondance and Press	2

169	British agrochem assocaition : 2,4,5-t	11/12/79	Press release	3
–	Confernce on 2,4,5-T	11/19/79	american farm bureau	3
171	CAST- A plague on our children	12/1/79	–	3
173	Discusion on the suspension of 2,4,5-T	1/23/80	by James M. Witt, EPA Alsea 2	1
200	EPA and DOW Risk Briefs	1/25/80	–	1
PB13/1 Vol 10	2,4,5-T	2/1/80	Correspondance and Press	2
220	Agchem Board press release	3/24/80	–	2
PB3/1 Vol11	2,4,5-T	5/26/80	Correspondance and Press	3
330	UK dioxin info?	11/3/80	–	2
PB13/1 Vol 12	2,4,5-T	1/1/82	Correspondance and Press	2
PB13/1 Vol 13	2,4,5-T	1/1/83	Correspondance and Press	2
EHC 29	2,4-D	1/1/84	WHO	3
Dept of Health	health effects of manufacture of 2,4,5-T	9/1/85	–	3
IPCS	Acrylonitrile HSG	1/1/86	2,4-D attached	3
	The use of 2,4,5-T in NZ	8/1/86	Enviromental council report	3
3757	Rhone Poulence MCPA	11/13/86	Registration File	1
Paper 29/4	Possible health effects of manufacture of 2,4,5-T	10/1/87	New Plymouth-MoH	3
2/1/2 vol 2	Letters to and from the chairman of the PB	2/25/88	–	2
A	2,4,5-T and Dioxins in sheepmeats	11/1/89	–	3
	FDA residue monitoring 1993	1/1/93	–	
DRIFT	Spray Drift incident	9/2/96	2,4-D	3
	Headland Spear	?	MCPA Tox file	1
PB3/1 Vol7	2,4,5-T - special	?	Papers to court hearing	1

Appendix 3 Letters received from DowAgroSciences (NZ) Ltd in response to requests for information

Dow AgroSciences (NZ) Limited
89 Paritutu Road
Private Bag 2017
New Plymouth 4620,
New Zealand
Phone 06-751 2400
Fax 06-751 0442
06-751 2858

Dow AgroSciences

2 April 2003

Bruce Wilblood-Crawford
University of Canterbury
Department of Geography
Private Bag 4800
CHRISTCHURCH

Dear Bruce

Thank you for your letter regarding your proposed PhD study.

The topic you propose to review is a very large one and one on which a very large amount of information is available. Dow AgroSciences has responded to this question in great detail over many years in a large number of publicly available documents and don't feel there is anything additional we can add.

Hence we don't feel there is anything to be gained by meeting with you at this stage.

We do wish you well with your studies.

Yours sincerely

Peter Dryden
General Manager

Dow AgroSciences (NZ) Limited
89 Paritutu Road
Private Bag 2017
New Plymouth 4620.
New Zealand
Phone 06-751 2400
Fax 06-751 0442
06-751 2858

Dow AgroSciences

15 June 2007

Bruce Wildblood-Crawford
1106 Miranda Road
R D 3
POKENO

Dear Bruce

Thank you for your letter. As the matters pertaining to 2,4,5-T and dioxin are of an historical nature and have been debated widely in the public domain many times we feel there is little value in further comment from Dow AgroSciences at this time.

Again, thank you for your interest.

Yours faithfully

Peter Dryden
General Manager

Appendix 4 Submission made to the Accident Compensation Commission detailing the potential of dioxin contamination of 2,4-D

College of Science

Department of Geography

Tel: +64 3 3667001, Fax: + 64 364 2907

December 4, 2006

RE: ACC case: *–name redacted to preserve confidentiality–*

Dear Mrs. Stringleman,

I have been asked to provide information regarding the above ACC case. I am currently a Doctoral Candidate at the University of Canterbury, Department of Geography. For the last 3.5 years I have been researching the social and political history of dioxins in New Zealand, particularly the case of 2,4,5-T.

I have been asked to comment on A) the authenticity of several documents being used as evidence in the above applicants case that relate to dioxins in 2,4-D and B) to offer any insights into what is known about dioxin contamination of 2,4-D.

A) The following documents have been accessed by myself during archival work on my PhD and are to the best of my knowledge accurate. I have included numbered copies of these documents and these have been submitted via post.

1. Watts (Ag. Chem. Board) to Bates (Dept. of Health), Nov. 11, 1980, 1 page
2. Watts (Ag. Chem. Board) to All Board Members (Ag. Chem. Board), Feb. 10, 1981, 1 page

3. Unclassified Routine Cable from Ottawa to Wellington, Feb. 4, 1981, 3 pages
4. Watts (Ag. Chem. Board) to Dr. W.P. Cochrane, March 27, 1980, 1 page
5. Bates (Dept. of Health) to Registrar (Ag. Chem. Board), Feb. 13, 1981, 1 page
6. Bates (Dept. of Health) Minute Sheet, Feb. 9, 1973, 1 page
7. Bates (Dept. of Health) to Registrar (Ag. Chem. Board), March 9, 1973, 1 page

Items #6 and #7 were cited at National Archives, Wellington and I recorded their contents. Thus they are transcripts, not originals. However I am confident their content as transcribed is accurate. These documents and #1- #5 are publicly available at the National Archives Wellington under the following references:

- ABQU, 632, W4415, 357, 156/11/48, 53116, Poisons/substances/Hormone Weedkillers

- ABQU, 632, W4415, 357, 156/11/48, 56251, Poisons/substances/Hormone Weedkillers

B) The preceding documents indicate that in perhaps the early 1970s, and definitely by the early 1980s, the New Zealand government was aware of dioxin contamination in 2,4-D. However, what has not been publicly disclosed is what investigations and tests on New Zealand 2,4-D were carried out. Likely such tests occurred, but I have been unable to locate them in the public record. They most likely reside in DSIR and Agricultural Chemical Board/Pesticide Board files.

Concerning Mr. ______'s case at least two key questions are outstanding: what were the levels of dioxin contamination in 2,4-D prior to the 1980's and was 2,4-D contaminated with high levels of TCDD? The following are three of the only publicly available excerpts regarding this topic.

The World Health Organisation [WHO] (1989) notes,

> Higher reaction temperatures and alkaline conditions during the manufacture of 2,4-D increase the formation of polychlorinated dibenzo- *p* -dioxin (CDD) by-products. One formulation of 2,4-D was found to contain 6.8 μg/kg of 2,3,7,8- tetrachlorinated dibenzo- *para* -dioxin (Hagenmaier, 1986). In other amine and ester formulations, levels of this dioxin were non- detectable, i.e., < 1 μg/kg (WHO 1989: 6).

Similarly, the Canadian Pest Management Regulatory Agency in 2005 [CPMRA] stated,

> In 1983, the manufacturing process for 2,4-D was modified, and a production limit of "not detectable at 1 ppb" was established for 2,3,7,8-tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD). Based on the current manufacturing process, the precursor phenol (2,4,5-trichlorophenol) that forms 2,3,7,8-substituted isomers is not used to manufacture 2,4-D. Furthermore, as a result of the review in 1981, improved methods of synthesis are employed to lower the levels of non-2,3,7,8-substituted dioxins in 2,4-D. Thus, with refined manufacturing processes, contamination of 2,4-D with dioxins and furans is not seen, nor is it expected may form 2,7-

> dichlorodibenzo- p-dioxin, while trichlorophenols may give rise to a mixture of 1,3,6,8- and 1,3,7,9-tetrachlorodibenzo- p-dioxins (but not 2,3,7,8-TCDD) by self-condensation, or to 1,3,7- trichlorodibenzo- p-dioxin (CPMRA 2005: 12).

In 2000, the New Zealand Pesticides Board conducted a review on 2,4-D (Pesticides Board 2000). Regarding dioxins in 2,4-D they noted that,

> …the US EPA draft document on dioxin showed that that highest concentration of the most toxic dioxin (2,3,7,8-TCDD) was only slightly above the limit of quantification of the analytical method (0.13 below the limit of quantification). Consequently, it has only been relatively recently that the presence of this dioxin was detected in 2,4-D. These levels are clearly lower than the level of 10µg/kg, which is the level accepted by the WHO in the herbicide 2,4,5-T that does not increasing the toxicity of the technical material. The levels of dioxin in 2,4-D would be unlikely to be detectable in formulated products. The Panel agreed that the dioxins were not considered to be significant impurities because the concentration of the dioxins and their related dibenzofuran congeners present in 2,4-D were on average 0.7µg/kg as toxic equivalents of 2,3,7,8-TCDD, which is lower than the 10µg/kg level accepted by the WHO (Pesticides Board 2000: 3).

From these sources, two ideas emerge. First is that numerous non-TCDD dioxins besides TCDD characterise the dioxin profile of 2,4-D. Second is that TCDD has clearly been found in 2,4-D in the past. Whether this is a result of the actual production process forming dioxins (as in 2,4,5-T), or via cross contamination, or both, is unclear. The Hagenmaier findings of 6.8 ppb TCDD in 2,4-D in WHO (1989) give our only indication of what *1980* levels might have been like. I think it is however fair to assume that the TCDD levels found in the early 1980's **do not** reflect historic levels. This is because, like 2,4,5-T, the manufacturers had already taken steps to 'clean up' production processes and final products.

Historic levels of dioxin production in 2,4-D are unknown but between 1950-1980's the levels in 2,4,5-T appeared to fluctuate based on production conditions. If the manufacturers were careful, dioxin 'production' was low, while during hurried production dioxin levels could rise by orders of magnitude. In addition, the manufacturer of chemicals always results in some proportion of 'off-spec products', ones that for a variety of reasons are not suitable for the regular commercial market. With 2,4,5-T and perhaps with 2,4-D, high dioxin content might have resulted in a batch of product being regarded as off spec. One use of such off-spec products in the past was likely in large commercial contracts; particularly those that would be applied aerially and in non-or lower populated areas. Thus one could fairly speculate that 2,4-D and superphosphate mixes would have been prime candidates for potentially higher dioxin 2,4-D.

Finally, I think it is important to point out that internationally and within New Zealand information about dioxins has been obscured and manipulated. Most researchers on dioxins would agree that both industry and government have not operated with a high degree of ethical integrity in informing the public and health officials about potential risks to human and environmental health. Thus, in the case of 2,4,5-T and particularly in the case of 2,4-D, we simply don't know what historic levels of dioxins were in these chemicals, as the chemical industry and/or governments have never provided this information. While no evidence that is currently available points to high levels of TCDD contamination of 2,4-D, it is equally true to say we have no evidence that says the opposite. Considering what we do know, it is my opinion that 2,4-D produced in chemical plant areas where high dioxin content 2,4,5-T was produced, would have unknown, but significant levels of TCDD and other dioxins that would be considered very high by today's standards.

I hope this information is helpful to the reviewers. Please let me know if you have any questions or need any comments extended or clarified. I can be reached at:

Cheers,

Bruce Wildblood-Crawford
1106 Miranda Road
RD 3
Pokeno
(w) 09-232-2501
(h) 09-232-7803
(c) 027-2809713
bsc22@student.canterbury.ac.nz

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Appendix 5

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Geo-Ed

Grassland utopia and *Silent Spring*: Rereading the agrichemical revolution in New Zealand

Bruce Wildblood-Crawford
Department of Geography, University of Canterbury, Private Bag 4800, Christchurch, New Zealand

Abstract: This paper explores the post-World War II 'green revolution' in agricultural chemicals and its representation in *Service*, a New Zealand chemical industry journal. In particular, I describe how various 'texts' within the journal constructed the revolution largely in utopian terms. Critically rereading these texts reveals the extent to which chemical use in agriculture was tied to post-war discourses of unwavering optimism about science, technology and progress.

Key words: agricultural history, chemical industry, discourse, New Zealand.

The post-World War II boom in synthetic chemicals heralded a 'green revolution' in agriculture that increased yields and transformed agricultural practices on an unprecedented scale. With an export trade traditionally based primarily on agriculture, New Zealand in many ways epitomizes the chemical successes of this revolution. Between 1920 and 1960 it increased pasture production and yields threefold while reducing labour inputs. This was not due solely to synthetic chemical inputs, but DDT, superphosphate fertilizers, the phenoxy herbicides 2,4-D and 2,4,5-T, and approximately 15 000 other chemicals in widespread use by 1960 did greatly facilitate the creation of the country's 'grassland utopia' in the post-war decades (Galbreath 1998: 72).

This paper seeks to show how these early decades of the green revolution were dominated by idealistic notions about science, progress and chemical use. It also aims to illustrate how such ideas were represented through images and prose and how these representations can be used for a critical reassessment of the past.

Contesting the green revolution

Despite the profound significance of synthetic chemicals, many New Zealand agricultural histories have constructed the reliance upon them in simplistic and uncontested terms (e.g. Smallfield 1970; Cumberland 1981). Such histories tend to treat the green revolution as a taken-for-granted aspect of agricultural improvement and, in so doing, minimize the social, cultural and economic landscapes that synthetic chemicals created and sustained. Brooking *et al.* (2002) have suggested that such insulation from critique is partly because chemicals were tied inextricably to an almost religious faith in the power of agricultural science to secure a prosperous future for New Zealand.

Here, I seek to further unpack these connections by examining various discourses employed by the chemical industry in New Zealand to defend and legitimate agricultural chemical use. In particular, I explore the emergence and construction of these discourses between 1959 and 1969 in the pages of *Service*, a New Zealand chemical industry journal.

Note about author: Bruce Wildblood-Crawford is a Doctoral Candidate in Geography at the University of Canterbury. His research focuses on the social and political history of dioxins and 2,4,5-T in New Zealand.

E-mail: bsc22@student.canterbury.ac.nz

Examining these discourses gives insight into how the agricultural chemicals of the green revolution simultaneously informed, and were informed by, the zealous attitude towards science and progress so prevalent in the post-war decades of the 1950s and 1960s.

The discursive construction of agricultural chemicals has received limited attention in the academic literature (Lockie 1997, 2001). 'Discourse' is used here in the broadest Foucauldian sense to mean a systematic set of statements or signs represented in various texts (Foucault 1972). In the following examination of *Service*, 'text' will include not just an analysis of article titles and prose, but also other representations of meaning such as cartoons, diagrams and photographic images. Discourses can also be thought of as frameworks that shape what can be said and that construct the 'rules' determining the criteria for what counts as truth. The choice of *Service* and the 1959–1969 time period represent an excellent opportunity to deconstruct discourses of science, chemical use and national progress.

First, while most of the 1950s can be viewed as the heyday of agricultural chemical use, the closing of the decade was marked by the emergence of sustained challenges to the hegemonic status of chemical industry products as generally safe for human and environmental health. In 1959, the New Zealand government made two significant moves, resulting in Amendment no. 12 to the 1946 Food and Drug Regulations and the Agricultural Chemicals Act. These initiatives, similar to laws passed in the US and UK during the same period, sought to address chemical residues in food products and increasing rates of accidental poisoning, in part through the creation of the Agricultural Chemicals Board. Second, the 1962 publication of Rachel Carson's *Silent Spring* initiated the first sustained public discussion, internationally and within New Zealand, about industrial chemicals and the possibility that human and wider ecosystem health might be compromised by their use. These events created spaces where the hegemonic ideal of agricultural chemicals would begin to be penetrated, contested and yet also reinforced.

Within New Zealand, a prominent contributor to such debates was the New Plymouth-based chemical manufacturer Ivon Watkins Ltd. Known today as Dow AgroSciences (NZ) Ltd, Ivon Watkins Ltd was formed in 1944 by three New Zealand brothers and subsequently became Ivon Watkins-Dow Ltd when Dow Chemicals USA. bought a 50 per cent share in the company in 1964. *Service: A Review of Agricultural and Chemical Progress* was a trade magazine published quarterly by Ivon Watkins Ltd between 1957 and 1973. Issued to an audience numbering 'five figures' (Ivon Watkins Ltd 1959: 3), *Service* is an ideal archive to explore the ruptures to, and defences of, the hegemony of agricultural chemical use.

While the pages of *Service* contained numerous iconic advertisements for the company's products (e.g. Fig. 1), according to the first issue's lead editorial, the journal was primarily 'intended to aid production by suggesting economical, efficient short-cuts to higher output by both preventative and corrective actions. It is addressed to the smallholder and the runholder, and all those between these limits, for all have a vested interest in stepping up production from their land' (Ivon Watkins Ltd 1956: 26).

However, post-1959 and increasingly after the release of *Silent Spring*, the journal was replete with editorials, opinion pieces, advertisements and reprinted overseas articles that, usually in explicit and bold terms, laid claim to the safety, legitimacy and necessity of agricultural chemicals. In doing so, these texts drew heavily upon utopian ideals about progress, scientific rationality and agricultural productivity that were pervasive internationally and within New Zealand. Next, I turn to examine several of the underlying discourses and in particular the ways in which they were represented in these various texts.

Bugs or people?

Perhaps the most frequent discourse found in *Service* after 1959, and particularly post-*Silent Spring*, linked two notions around issues of global food supply. First was the neo-Darwinian idea that humanity was locked in a battle against insects for control of nature's food supply. Second, and closely related, was that of a global population explosion and the looming food shortage that was seen as inevitable. Both of these interwoven themes were usually

Figure 1 Typical advertisement for agricultural chemicals found in *Service* (Ivon Watkins Ltd. 1960b). Reprinted by permission of Dow AgroSciences (NZ) Ltd.

presented explicitly as defences against the emerging contestations over agricultural chemicals, and we can also see strong links to the ideals of scientific rationality, national progress and New Zealand's global role in securing a prosperous future for all.

The use of agricultural chemicals is portrayed throughout *Service* as fundamentally necessary to humanity's survival and as weapons in a war against insects and disease (Fig. 2). 'How poisonous are the modern insecticides?' notes that,

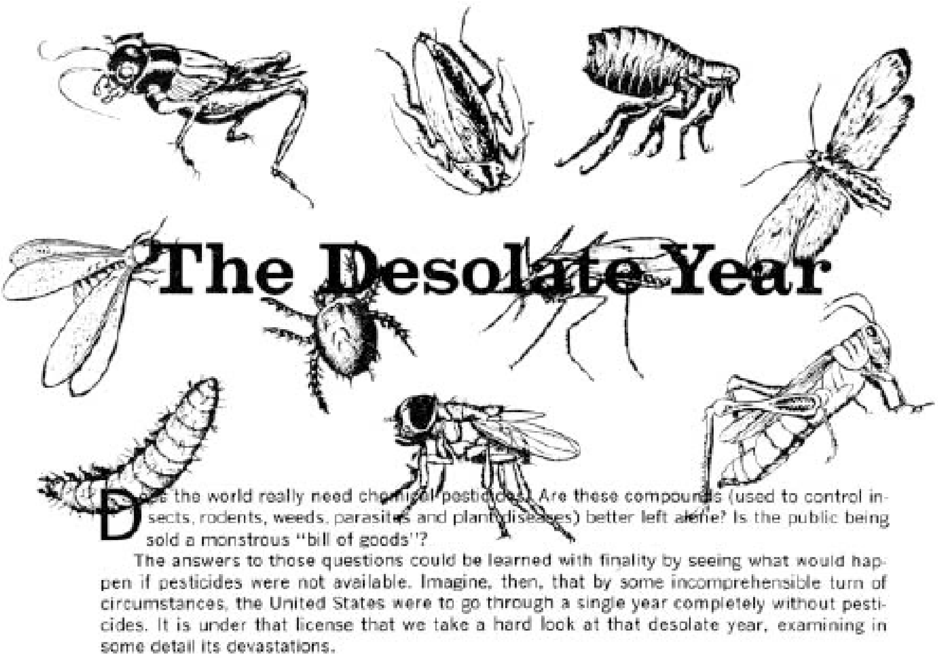
> 'Given half a chance many of these plagues would destroy vast tracts of productive country, laying waste and famine in their path. Other insect parasites, the malaria-carrying mosquito or the rat flea, can spark off disease across whole continents. Is this state of affairs to be preferred simply because the modern insecticide, essentially a safe product, might occasionally injure man, but, mark you, far less frequently than the motor car ... ?' (Ivon Watkins Ltd 1962b: 23)

Figure 2 Article heading portraying the 'war' between humanity and nature (Ivon Watkins Ltd. 1957). Reprinted by permission of Dow AgroSciences (NZ) Ltd.

Throughout articles like 'Pests beat people for a large portion of the world's food' (Ivon Watkins-Dow Ltd 1967–68b: 18) and 'The alternative to pesticides is easily predicted' (Ivon Watkins-Dow Ltd 1964: 30) insects are pitched in a timeless battle against humanity over resources. They are accorded considerable respect and are shown as being bestowed with anthropocentric qualities like determination, domination and tenacity. These qualities are used to highlight the seemingly endless potential of natural forces to overwhelm food production and cripple progress. 'The Desolate Year' (Fig. 3), reprinted from the US chemical company publication *Monsanto Magazine*, highlights such a doomsday scenario by describing 'the incomprehensible turn of circumstances' (Ivon Watkins Ltd 1963: 26) that would result if the USA went without pesticides for one year. As 'the garrote of Nature rampant began to tighten … food and fur animals weren't the only ones that died to the hum of insects that year. Man, too, sickened and he died' (Ivon Watkins Ltd 1963: 27).

This discourse of war between humans and insects was constructed throughout *Service* in evolutionary terms. A progression of control over nature through time, manifested by science and technologies like chemicals, was romanticized through reference to pre-modern and modern times. The cartoon shown in Figure 4 constructs pre-modern nature as both mysterious and powerful. Yet, this past lack of control is juxtaposed against the modern use of scientific technologies to control and minimize the wrath of nature. Chemical use was thus naturalized as part of a linear progression of humanity's greater control over natural forces.

The discourse of 'Bugs or people?' was given further credence through reference to themes of food supply, population and progress. Frequently, the potential damage that non-chemically controlled insects could inflict on national economic goals was stated in blunt, yet simplistic terms. For instance 'Counting the costs if pests are not controlled' notes that 'insects alone cost the farmer more than 1 000 million pounds sterling and nullify the work of over a million farm workers' (Ivon Watkins-Dow Ltd. 1965b: 23). Similarly, the *Spring* 1960 lead editorial in *Service* stated that 'the continued use of chemicals to control pests and disease is imperative


The Desolate Year

Does the world really need chemical pesticides? Are these compounds (used to control insects, rodents, weeds, parasites and plant diseases) better left alone? Is the public being sold a monstrous "bill of goods"?

The answers to those questions could be learned with finality by seeing what would happen if pesticides were not available. Imagine, then, that by some incomprehensible turn of circumstances, the United States were to go through a single year completely without pesticides. It is under that license that we take a hard look at that desolate year, examining in some detail its devastations.

Figure 3 Title and text from an article that discusses the repercussions of going one year without chemical pesticides (Ivon Watkins Ltd 1963). Reprinted by permission of Dow AgroSciences (NZ) Ltd.

if the world's need for more and better quality food is to be fulfilled' (Ivon Watkins Ltd 1960a: 2). Other articles like 'Chemicals or starvation?' (Ivon Watkins-Dow Ltd 1965a: 12) and 'Nothing to eat in stupidity street' (Ivon Watkins-Dow Ltd 1967: 3) further linked New Zealand's ability to increase food production as not only imperative to national prosperity, but also as a prerequisite to being a good global citizen.

A patient and caring science

Another prominent discourse revolved around the construction of science as a singular, powerful and moral way of knowing. The perspective of scientific rationality presented in *Service* discounted other ways of knowing, and portrayed chemical industry science as a careful and consciousness process free of commercial influence. This section discusses two ways this discourse of science was constructed throughout the journal: as a value-free site of scientific consciousness, and the representation of *Silent Spring* as being based solely on emotional innuendo, not 'objective' fact.

A primary focus of late 1950s legislation was on minimizing negative impacts of chemical use on agricultural products. Chemical residues in food had generated anxiety that chemicals were being rushed to the market place without adequate testing and that some manufacturers were releasing poor quality products. Within *Service* such accusations elicited a defence of science as a principled and guiding force within the chemical industry. While not stated in terms as blunt as the 'Bugs or people?' discourse, a common feature of this defence was the construction of science as not only objective, but as a caring, patient and conscientious pathway to knowledge. Part of this approach was the time it took new chemicals to reach the marketplace. In minute detail, numerous articles detailed how science slowly and methodically screened and developed new chemicals. For instance, 'Science is patient and cautious, that is why a new chemical can be five years old before it reaches the user' states: 'The agricultural chemical industry is acutely aware of its responsibilities … That is why its research workers, scientists and chemists

Figure 4 One of a series of cartoons that constructed progress in terms of increasing human control over nature (Ivon Watkins-Dow Ltd 1967–68a). Reprinted by permission of Dow AgroSciences (NZ) Ltd.

are painstaking in their screening of new chemicals, and companies are prepared to invest heavily in long-term testing' (Ivon Watkins Ltd 1961a: 13).

Frequently the laboratory was constructed as the site of this rational approach to safety. The objective rigour of science bestowed the laboratory with a conscience that was seemingly unconnected to commercial pressures. The images in Figure 5 draw upon these notions of a slow, patient and caring science where the lab 'is expected to exercise its responsibility to the company and the users of the company's products without fear of any sort. Objection by those in charge of quality control can stop the processes of production irrespective of urgency, irrespective of cost' (Ivon Watkins-Dow Ltd 1969: 25).

Infusing science with emotions naturalized the caring and conscientious discourse of science as a fundamental quality much in the same way that the 'Bugs or people?' discourse naturalized the notion of technology as a progression from pre-modern to modern.

Finally, reverence for the rationality of science can be seen in texts that sought to discredit Carson's *Silent Spring*. A central issue disputed within *Service* was Carson's hypothesis that sub-lethal doses of pesticides might slowly cause human and animal health problems over time. Such a hypothesis was immediately discounted in 1962 as having no basis in established facts. However, many of Carson's arguments and those that began appearing in the popular media questioned the use of agricultural chemicals on moral and ethical grounds. The industry response evident in *Service* never engaged with these arguments. Instead, the most widespread response was a continual reverence for the ability of science to establish norms and facts. For instance an article entitled 'It's easy to fear the wrong things' stated that 'the struggle between fiction, fear and fact has been an unequal battle. When a public figure presses the panic button, we forget that we have developed controls and specific rituals of proper usage and laws to enforce them' (Ivon Watkins Ltd 1961b: 27).

But further to this, many articles in *Service* stressed that emotional factors, particularly fear of progress, lay at the heart of Carson's thesis. Dan Watkins, an Ivon Watkins director, stated in a *Service* editorial entitled 'The not-so-deadly *Silent Spring*' that 'we envy the inspiration that dredged up from heaven knows what emotional depths the persuasive title, *Silent Spring*' (Ivon Watkins Ltd 1962a: 3). This interplay between 'established' facts and emotions acted to drown out any critique of the hegemonic positioning of science or possible alternative ways of conceptualizing chemical use.

Conclusion

This paper has discussed how the post-World War II green revolution in synthetic chemicals transformed New Zealand agriculture and was

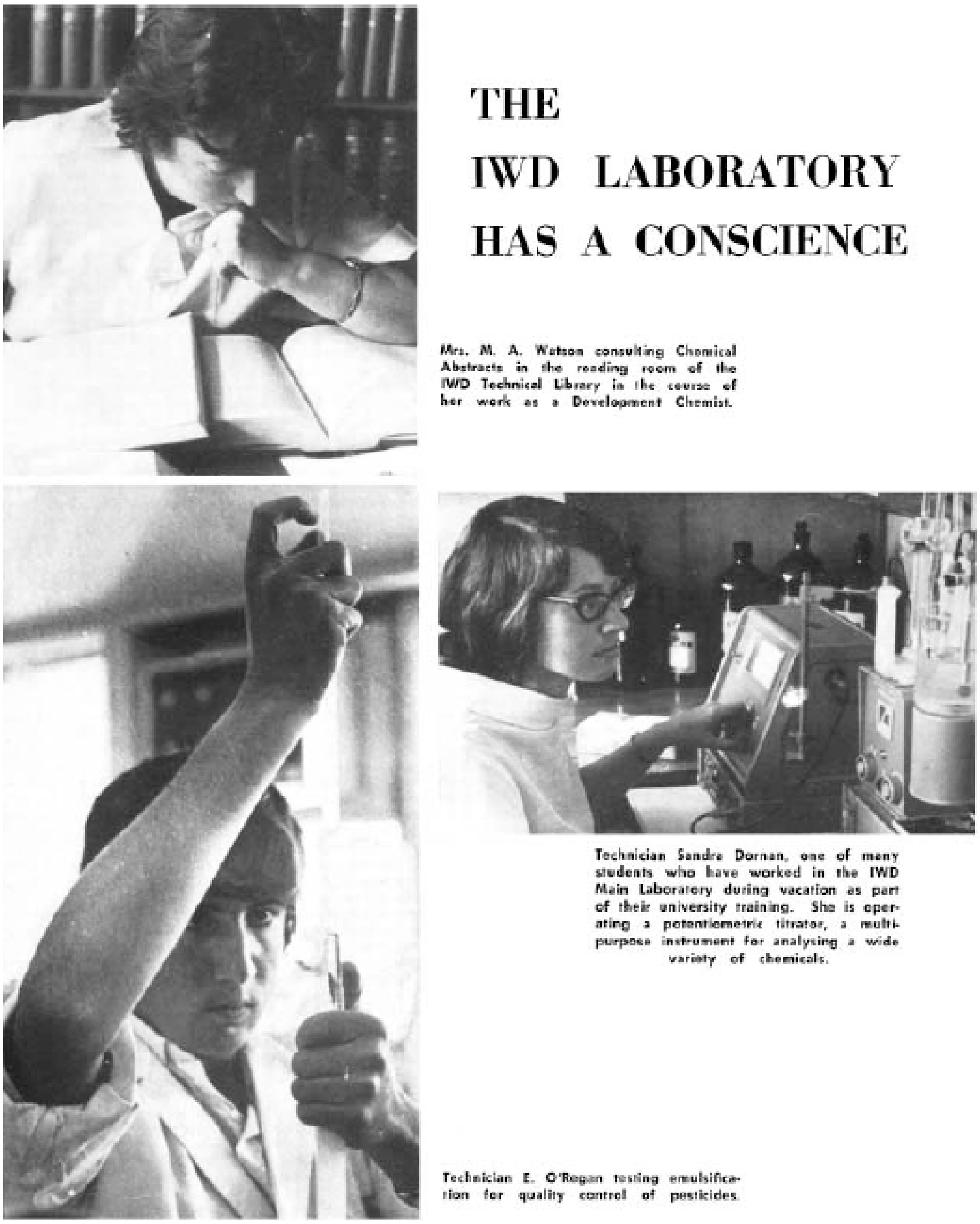


Figure 5 Photographs that sought to portray the 'human' side of science (Ivon Watkins-Dow Ltd 1969). Reprinted by permission of Dow AgroSciences (NZ) Ltd.

interpreted in a progressive way. Today, the same chemicals are often seen in anything but this light. This shift in representation can be seen in the ways we interpret texts and how such re-readings often highlight and contest dominant ideas of the past. Such disjunctures are useful ones to focus on in classroom teaching or in writing assignments, and can give students some insight into the critical assessment of how things change over time.

Acknowledgements

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